An Evaluation of the VISION Execution System Demonstration Prototypes

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The research described in this report was sponsored by the United States Army, Contract No. MDA903-91-C-0006.

Library of Congress Cataloging in Publication Data

An evaluation of the VISION execution system demonstration prototypes / Patricia M. Boren . . . [et al.].
p. cm.
"Prepared for the United States Army."
Includes bibliographical references.
"R-3967-A."
ISBN-0-8330-1113-8
1. United States. Army—Equipment—Maintenance and repair.
2. United States. Army—Weapons systems—Maintenance and repair.
3. United States. Army—Inventory control. 4. United States.
Army—Data processing. 5. United States. Army—Combat
sustainability. I. Boren, Patricia M., 1955–
II. RAND Corporation. III. United States. Army.
UC263.E93 1991
355.8—dc20 90-27778
CIP

Published 1991 by RAND
1700 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138

R-3967-A

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PREFACE

This report describes the prototype development for a U.S. Army combat-oriented logistics execution system with VISION (Visibility of Support Options). It is the third in a series that describes concepts for logistics decision support systems aimed at improving the wartime and peacetime availability of important U.S. Army weapon systems through improved management of Class IX items (though the concept is in principle applicable to other classes of supply). The other reports in the series are:

- R-3702-A, *The Concept of Operations for a U.S. Army Combat-Oriented Logistics Execution System with VISION (Visibility of Support Options)*, Robert S. Tripp, Morton B. Berman, Christopher L. Tsai, March 1990.
- R-3968-A, *The VISION Assessment System: Class IX Sustainment Planning,* Christopher L. Tsai, Robert S. Tripp, and Morton B. Berman, forthcoming.

The first report describes an execution system that prioritizes repair and distribution of spare parts by maximizing the probability of meeting unit-level weapon system availability goals. The Army has incorporated the main ideas of the execution system into the Readiness Based Maintenance System (RBMS), identified as an important element of the Strategic Logistics Plan (SLP). Originally outlined as a first priority of development in the Army Materiel Command (AMC) Standard System (AMCSS), the SLP is now coordinated by the Strategic Logistics Agency (SLA) under management of the Deputy Chief of Staff for Logistics.

The second report outlines a concept to help logisticians assess the sustainability of various groupings of combat units—from a brigade to an entire theater—against a number of specific scenarios. This assessment system identifies proposed problem resources and processes likely to limit the achievement of desired weapon system availability goals at specific time intervals during the scenario.

This report describes the results of developing demonstration prototypes of the execution system concept described in R-3702-A.

This research is part of the Readiness and Sustainability Program of the Arroyo Center. The research project, entitled "Logistics Management System Concepts To Improve Weapon Systems Combat

Capability," is jointly sponsored by the Assistant Deputy for Materiel Readiness of the AMC, the Commanding General of the Combined Arms Support Command (CASCOM), and the Director of the SLA. This research should be of interest within AMC, Army Headquarters, and CASCOM; it should also be of interest to readers throughout the Army logistics community.

THE ARROYO CENTER

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Army Regulation 5-21 contains basic policy for the conduct of the Arroyo Center. The Army provides continuing guidance and oversight through the Arroyo Center Policy Committee, which is cochaired by the Vice Chief of Staff and by the Assistant Secretary for Research, Development, and Acquisition. Arroyo Center work is performed under contract MDA903-91-C-0006.

The Arroyo Center is housed in RAND's Army Research Division. RAND is a private, nonprofit institution that conducts analytic research on a wide range of public policy matters affecting the nation's security and welfare.

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SUMMARY

The VISION (Visibility of Support Options) concept pertains to a series of decision support systems designed to help U.S. Army logisticians manage resources and improve the availability of high-technology weapon systems in both peacetime and wartime environments. Three primary elements are identified:

- An execution system to guide maintenance and distribution actions;
- An assessment system to assist the sustainment planning process; and
- A command and control (C^2) system to translate information from the operations arena into the logistics needs of the execution and assessment functions.

THE NEED FOR VISION

The VISION concept was conceived to help the Army adapt to a radically changing world. Although the final shape of that future world still cannot be definitively described, it is likely to be characterized by uncertainty in the threat, the importance of short-term contingencies that require rapid responsiveness, a reliance on high-technology weapons as combat multipliers, and a shrunken resource base.

The new environment poses the greatest challenge for restructuring and rethinking the Army has faced in decades. It will not simply be a matter of scaling down; the Army will have to be rebuilt in innovative ways. Of paramount importance will be the concept of weapon system management. The Army Materiel Command (AMC) is developing the means to transform its management to a weapon system orientation. As the Army begins to build new structures, it also must devise management systems such as VISION that will help those organizations function effectively.

THE READINESS-BASED MAINTENANCE SYSTEM

The ideas included in the VISION execution system concept have been accepted by the Army and incorporated in the Readiness-Based

Maintenance System (RBMS), one of the four pillars of the Strategic Logistics Plan (SLP). The chief objective of RBMS is to enhance the contributions of combat service support (CSS) functions to the peacetime readiness and wartime sustainability of the combat force. The essence of RBMS is reflected in the two fundamental questions that it seeks to address:

- In view of operational needs, what is the ideal sequence in which to repair unserviceable assets?
- Once repaired, how are those assets most advantageously distributed among units in the field?

The concept calls for a series of hierarchical, decentralized RBMS modules that take into account differences in repair and distribution characteristics and responsibilities of various echelons. Each repair and distribution execution decision suggested by RBMS maximizes the probability of meeting unit-level weapon system availability goals and operating tempo requirements over a short time horizon.

TESTING THE RBMS CONCEPT

The final form of the RBMS network demands more analysis and development. Before that can occur, however, the value of the system on the whole must be demonstrated. Thus, the plan for testing the RBMS concept calls for the extensive use of prototypes. Two phases of prototyping are identified: one for demonstration purposes and one for a hands-on, operational version to be exercised by Army personnel. The experience gained through prototyping will ease any eventual implementation effort. Many of the obstacles that would otherwise impede full-scale development should be encountered and resolved within a controlled environment, thereby minimizing future disruption.

The prototypes feature high-cost, high-technology components. There are several reasons for this orientation. First, these items are more likely to use the complex, multi-echelon support structures that RBMS was specifically designed to address. Second, their cost and combat criticality make them leading candidates for inclusion in the asset tracking systems that RBMS exploits. Third, their low cube/weight factors encourage consideration of expedited shipping and handling, which are important aspects of responsive support. Finally, these items are often of the sort that share common test, measurement, and diagnostic equipment (TMDE). This introduces an element of contention for maintenance resources and so invites the notion of prioritization.

Three separate demonstration prototypes were chosen to examine the application of RBMS to different echelons. A division-level prototype encompasses the repair capability of the Direct Support Electrical System Test Set (DSESTS), used for fault diagnosis of sophisticated fire control and turret components on the M1 Abrams tank and M2/3 Bradley fighting vehicle. A theater-level prototype focuses on a contractor-run special repair activity (SRA) dedicated exclusively to support the Target Acquisition Designation Sight/Pilot Night Vision Sensor (TADS/PNVS) system of the AH-64 Apache attack helicopter. A depot-level prototype highlights the workload of the electro-optical shop at the Sacramento Army Depot, which fixes mostly night vision components on a wide range of weapon systems, including M1s and M2/3s.

RESULTS

The demonstration prototypes allowed RBMS to be developed and exercised through theoretical analyses in a laboratory-style environment. These analyses helped pinpoint the value of RBMS with regard to its feasibility, effectiveness, and usability.

Feasibility implies methodological suitability of the underlying DRIVE (Distribution and Repair In Variable Environments) algorithm.[1] DRIVE is used to interpret an input database and determine a priority sequence of repair and distribution actions across a planning horizon. As the demonstration prototypes developed, we gained new insights into the role of DRIVE. Although it has its shortcomings, with further enhancement the DRIVE model should be highly suitable to RBMS.

Another part of feasibility reflects data quality and availability. RBMS is a data-hungry system. It relies on operational data about the units and logistics data about weapon system components, both of which require a variety of sources and processing. The operational

[1]HQ USAF and HQ Air Force Logistics Command sponsored the work to develop DRIVE under a RAND study, "The Uncertainty Project." An operational prototype of the algorithm is being tested at the Ogden Air Logistics Center with the active participation of Air Force personnel. It is currently limited to F-16 peculiar aircraft avionics components repaired in the Avionics Integrated Shop and their shop replaceable units (SRUs) that are repaired in the SRU Repair Shop and Microwave Shop. A RAND report describing DRIVE is being prepared.

data—force composition, weapon system availability goals, and operating tempos—are often not collected or, at best, are difficult to obtain because they are dynamic and forward-looking by nature. In contrast, most of the logistics data are currently available from standard Army management information systems (STAMIS), but may require processing into a suitable format. For RBMS to reach its potential in helping relate logistics actions with combat goals, methods must be developed to routinely collect operational data. Also, new STAMIS under development will greatly enhance the logistics data gathering efforts necessary for RBMS.

RBMS is designed to be most effective when it receives accurate information. However, relative rates of activity among units can be used in the place of precise figures or estimates. The intent is to swing support to engaged units in an anticipatory fashion so that the system can respond quickly to unexpected demands.

The prototype evaluations also revealed the effectiveness of RBMS over the current system in increasing weapon system availabilities. Although the amount of payoff varied depending on the characteristics of the work center modeled, RBMS never had a negative affect on weapon system availability. In addition, RBMS apparently provides more flexible and responsive support at a lower cost than the current system.

Usability concerns the interaction between the user and the system, with particular regard to the policy and procedural implications of implementing RBMS in the real world. Interviews and demonstrations conducted with potential users indicated the users were favorably impressed with the RBMS concept. Users raised concerns about how the current way of doing business would have to change if RBMS were implemented. Issues ranging from changes in performance measures to ensuring the availability of bit-and-piece parts for repair should be thought through very carefully before RBMS is implemented.

FUTURE DIRECTIONS

The next step in the RBMS development process is to formulate a set of operational prototypes. Such a set will serve the dual purpose of exposing RBMS to real-world conditions and providing hands-on experience for potential users. Moreover, the prototypes will lay the groundwork for continued exploration and progress toward formal system implementation by permitting us to adapt the system operations to the realities of life.

We recommend that two major policy issues be studied and tested with the operational prototypes: the type of distribution policy (perhaps a mix of "push-pull" strategies to help achieve the rapid responsiveness that will be demanded in operations such as short-term contingencies) and a policy for redirecting assets incoming from higher echelons (if any).

It should be emphasized that RBMS can be only one part of an overall system redesign. It cannot, acting by itself, optimize repairs and distributions or achieve weapon system availability goals. RBMS is, at root, little more than a computer algorithm. It is, however, part of an overall system predicated on weapon system management, including new information systems, policies and procedures, management authority, and divisions of responsibility between users and supporters.

Further research is required for the RBMS concept to realize its full potential. Important issues to explore include:

- Criteria for selecting work centers and items that should be managed by a system like RBMS;
- Methods to coordinate workloads across multiple work centers that repair items on the same weapon system;
- Procedures to connect the operations and logistics communities and elicit C^2 information;
- Strategies to determine the most cost effective way to maintain an adequate stock of repair parts to ensure weapon system availabilities;
- Estimating the costs of developing and implementing RBMS within the Army.

As the Army moves toward its weapon system management goal, RBMS can play a vital role in adding crucial new management capabilities.

ACKNOWLEDGMENTS

The authors would like to express their appreciation to several RAND colleagues who helped shape the ideas contained in this report. Morton Berman supported the early idea that information systems were important force structure elements of the Army. He pushed for building prototypes to learn how the systems could function in the Army environment and continued to demand, in the finest of RAND traditions, that we provide objective quantitative analyses of the payoffs of the VISION concepts. John Abell and Louis Miller eagerly provided technical guidance with regard to the model underlying RBMS, which they developed and modified to meet Army needs. Christopher Tsai worked with Lou Miller to develop a computer demonstration of RBMS, which he successfully took to senior Army executives to explain how the system could work. John Abell and Kenneth Girardini provided careful reviews of this report that greatly enhanced its content. Betsy Sullivan helped prepare several iterations of the manuscript.

Jeffrey Crisci and Cecilia Butler, formerly of the Army Materiel Command (AMC) and currently with the Strategic Logistics Agency (SLA), were instrumental in providing contacts and access to Army data and facilities, not only within AMC but across HQ Department of the Army and major commands within the Army, that enabled this phase of the VISION project to be completed. They also took an advocacy role in pushing the project and the need to develop VISION prototypes. Without their help, the RBMS demonstration prototypes described here could not have been developed, nor could this report have been written.

CONTENTS

FIGURES

ABBREVIATIONS

ACR	Armored Cavalry Regiment
ADADS	Army Depot Automatic Diagnostic System
ADVANCE	Army Data Validation and Netting Capability Establishment
AIMI	Aviation Intensive Management Item
AMC	Army Materiel Command
AMCCOM	Armament, Munitions, Chemical Command
AMDF	Army Master Data File
AMSAA	Army Materiel Systems Analysis Activity
AMSS	Army Materiel Status System
AOAP	Army Oil Analysis Program
AR	Army Regulation
ASL	Authorized Stockage List
ATCCS	Army Tactical Command and Control System
AVIM	Aviation Intermediate Maintenance
AVSCOM	Aviation Systems Command
C^2	Command and Control
CAA	Concepts Analysis Agency
CASCOM	Combined Arms Support Command
CAV	Corps Asset Visibility
CBS–X	Continuing Balance System–Expanded
CCSS	Commodity Command Standard System
CECOM	Communications and Electronics Command
CDA	Catalog Data Activity
CDDB	Central Demand Data Base
CEDRS	Capability Engineering Data Reporting System
CMRP	Critical Maintenance Repair Parts
CONUS	Continental United States
CSS	Combat Service Support
DESCOM	Depot Systems Command
DODAAC	Department of Defense Activity Address Code
DRIVE	Distribution and Repair in Variable Environments
DSESTS	Direct Support Electrical System Test Set
EAC	Echelons Above Corps
EETF	Electronic Equipment Test Facility
EMC	Electronics Maintenance Company
EQUATE	Electronic Quality Assurance Test Equipment
FCFS	First Come, First Served

FEDC	Field Exercise Data Collection
FMC	Fully Mission Capable
FORSCOM	Forces Command
FSB	Forward Support Battalion
I&S	Interchangeable and Substitutable
IFTE	Integrated Family of Test Equipment
IM	Item Manager
IPR	In-Process Review
LCA	Logistics Control Activity
LIF	Logistics Intelligence File
LRU	Line Replaceable Unit
MCC	Movement Control Center
MICOM	Missile Command
MLRS	Multiple Launch Rocket System
MMC	Materiel Management Center
MRDB	Materiel Returns Data Base
MRSA	Materiel Readiness Support Activity
MSB	Main Support Battalion
MSC	Major Subordinate Command
MTD	Maintenance Task Distribution
MUBR	Mean Units Between Replacement
NFMC	Not Fully Mission Capable
NICP	National Inventory Control Point
NMCS	Not Mission Capable Supply
NSN	National Stock Number
NSNMDR	National Stock Number Master Data Record
O&S	Operation and Support
OSC	Objective Supply Capability
OST	Order and Ship Time
PLL	Prescribed Load List
PMR	Provisioning Master Record
POL	Petroleum, Oil, and Lubricants
QPA	Quantity Per Application
RBMS	Readiness-Based Maintenance System
RRAD	Red River Army Depot
SAAD	Sacramento Army Depot
SAMS	Standard Army Maintenance System
SARSS	Standard Army Retail Supply System
SDC	Sample Data Collection
SDS	Standard Depot System
SIMA	Systems Integration and Management Activity
SIMS–X	Selected Item Management System–Expanded

SLA	Strategic Logistics Agency
SLP	Strategic Logistics Program
SRA	Special Repair Activity
SRU	Shop Replaceable Unit
SSA	Supply Support Activity
STAMIS	Standard Army Management Information Systems
TACOM	Tank and Automotive Command
TADS/PNVS	Target Acquisition Designation Sight/Pilot Night Vision Sensor
TAMMS	The Army Maintenance Management System
TAV	Total Asset Visibility
TEDB	TAMMS Equipment Data Base
TMDE	Test, Measurement, and Diagnostic Equipment
TSTS	Thermal System Test Set
UBRD	Usage-Based Requirements Determination
UIC	Unit Identifier Code
UMMIPS	Uniform Materiel Movement Issue Priority System
VAS	VISION Assessment System
VISION	Visibility of Support Options
WOLF	Work Order Logistics File
WSMIS	Weapon System Management Information System

I. INTRODUCTION

THE VISION CONCEPT

VISION (Visibility of Support Options) is a series of decision support systems designed to help U.S. Army logisticians manage resources and improve the availability of high-technology weapon systems in both peacetime and wartime environments. Although the initial focus is upon the supply, maintenance, and distribution of Class IX commodities, the VISION concept is sufficiently general that it can be extended to other classes of supply.[1]

VISION consists of three primary elements: (1) an execution system to guide maintenance and distribution actions; (2) an assessment system to assist the sustainment planning process; and (3) a command and control (C^2) system to translate information from the operations arena into the logistics needs of the assessment and execution functions. Although each element is in a different stage of development, formal concepts have been developed.[2] Appendix A provides an overview of the total VISION system.

THE NEED FOR THE VISION CONCEPT

The VISION system can help the Army adapt to a radically changing world. The final shape of that future world is likely to be characterized by several features:

- Uncertainty in the threat;
- Importance of short-term contingencies, requiring rapid responsiveness;

[1]The Arroyo Center's Readiness and Sustainability Program supports similar research in the Class V arena as well. See J. F. Schank and B. Leverich, *Decision Support for the Wartime Theater Ammunition Distribution System: Research Accomplishments and Future Directions,* The RAND Corporation, R-3794-A, June 1990.

[2]The execution system is described in R. S. Tripp, M. B. Berman, and C. L. Tsai, *The Concept of Operations for a U.S. Army Combat-Oriented Logistics Execution System with VISION (Visibility of Support Options),* The RAND Corporation, R-3702-A, March 1990. The assessment system will be described in a forthcoming report by C. L. Tsai, R. S. Tripp, and M. B. Berman. The C^2 system will be dealt with in a third concept paper.

- Reliance on high-technology weapons as combat multipliers;
- A shrunken resource base.

Uncertainty in the Threat

The recent changes in the world situation portend a vastly different set of threats the Army must be able to face. There will no longer be a "canonical" Warsaw Pact threat for the Army to plan against. Instead, there may be any number of threats necessitating the use of force anywhere in the world and at any time. These adversaries are likely to be less well armed than the Soviet Union, but their forces may still be considerable. Added to that will be the disadvantages of distance and the possibility of entering unfriendly country—in all, the Army's challenge may be immense. The future Army must be able to deal with an array of adversaries, with unknowable demands for force sizes, weapon mixes, duration, and need for sustainment.

Importance of Short-Term Contingencies

The Army is likely to be based primarily in the continental United States (CONUS). In this sense, all operations can be considered "contingencies" in which Army forces must deploy to unprepared locations. These contingencies may occur with little or no warning, and must be successfully completed in a very short time, as was the case with Operation Just Cause in Panama, in December 1989. Such short-term contingencies will put immense pressure on the support system to be rapidly responsive. The fast pace and brief duration of the fighting will make it paramount that the right support go to the right units in the shortest time possible, or it will likely be too late to be useful.

Reliance on High-Technology Weapon Systems

Fighting anytime, anywhere in the world against any number of adversaries puts a burden on the Army to have quickly deployable systems that deliver large amounts of firepower. The obvious advantage the U.S. Army will have over armies like those of Iraq will be in its high-tech weaponry. But the reliance on high technology will come at the cost of easy or cheap supportability. Prior RAND research has examined the need for responsive, robust support of high-tech weapon systems;[3] the new world of contingency operations will make the need for robust support all the greater.

A Shrunken Resource Base

The Army must accomplish these missions in an environment of fewer resources than it has been accustomed to. There will no longer be a "standard threat" in Europe from which less demanding contingencies can be supported; all missions will have to be supported out of the same smaller resource base. This demands that the Army support structure be able to exploit the maximum of its fewer resources—and this at a time when the cost of supporting its weapon systems, particularly those relying on high-technology subsystems, is increasing.

Weapon System Management

This new environment poses the greatest challenge for restructuring and rethinking the Army has faced in decades. It will not simply be a matter of scaling down; the Army will have to be rebuilt in innovative ways. Of paramount importance will be the concept of weapon system management. The Army Materiel Command (AMC) is currently developing the means to transform its management to a weapon system orientation. Such tools as the VISION system are intended to help this effort.

Weapon system management entails changes in structures, roles, organizations, and concepts. It calls for new criteria of effectiveness and measures by which system and individual performance are judged. It demands as well new types of information and management systems geared to employing resources in ways to achieve weapon system availability goals. To allow logisticians to exploit their resources, it calls for "seamless" systems that provide visibility of all assets as well as current weapon system status.

To be responsive, the future system will have to pursue a mix of "push-pull" strategies. Pipeline times of line replaceable units (LRUs) and shop replaceable units (SRUs) must be shorter; the system must be as close as possible to being instantaneously reactive to unit needs,

[3]An informative discussion of uncertainty, system flexibility, and adaptation may be found in M. B. Berman, D. W. McIver, M. L. Robbins, and J. F. Schank, *Evaluating the Combat Payoff of Alternative Logistics Structures for High-Technology Subsystems*, The RAND Corporation, R-3673-A, October 1988.

especially in short-term contingencies. But the system must also anticipate future needs, especially those where longer lead times reduce the attainable responsiveness. Thus, for example, depot programmers must be able to determine current workloads on the basis of anticipating future needs in order to satisfy demands for limited spare parts just as they occur.

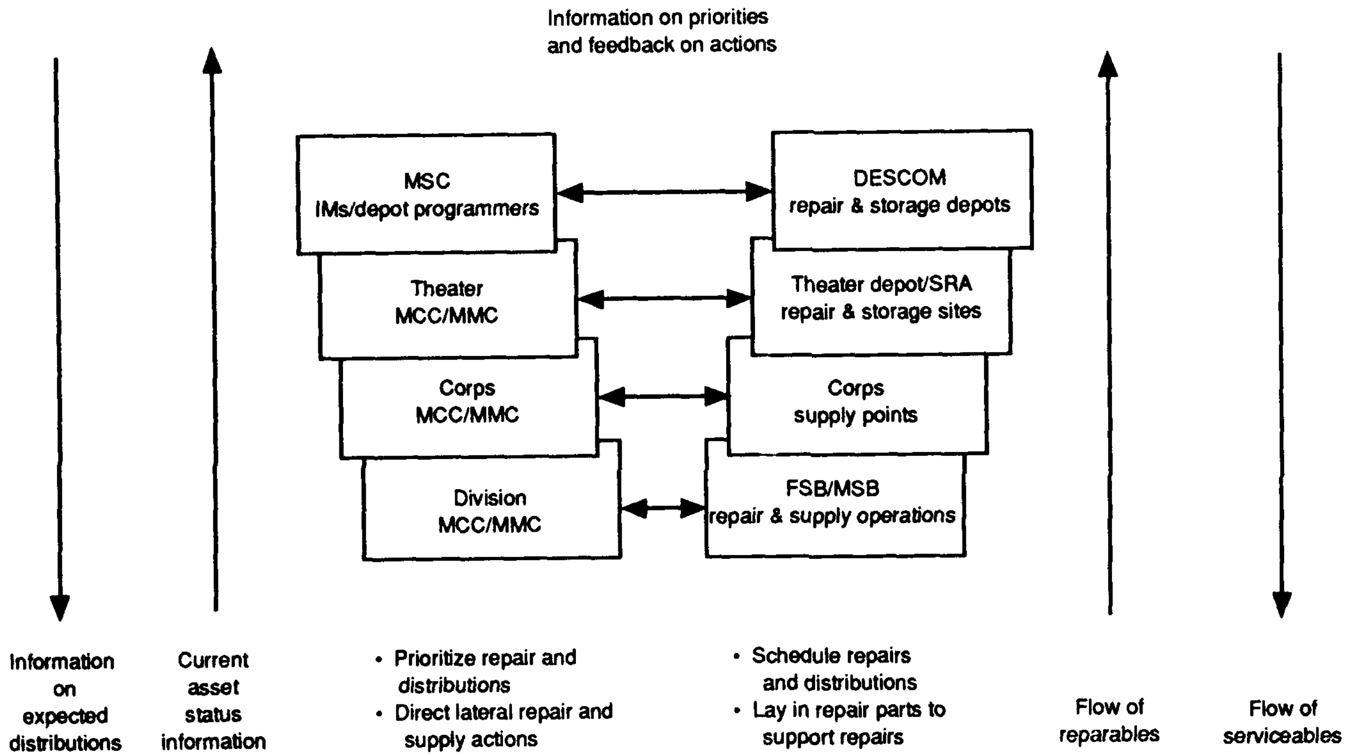
The Army, then, has begun building new structures to help it adapt to the new world. It needs in addition the management systems that will help these organizations function effectively. The VISION system was conceived and is being developed to help the Army in this effort.

This document describes one part of the VISION system, the VISION execution system. The ideas in the execution system concept have been incorporated in the Army's Readiness-Based Maintenance System (RBMS). An operational prototype of RBMS is being developed by the Strategic Logistics Agency (SLA) to test this concept in a real-world setting.

THE RBMS CONCEPT OF OPERATION

The chief objective of RBMS is to enhance the contributions of combat service support (CSS) functions to the peacetime readiness and wartime sustainability of the combat force. As shown in Fig. 1.1, the concept calls for a series of hierarchical, decentralized RBMS modules that take into account differences in repair and distribution characteristics and responsibilities of various echelons. RBMS can guide the actions of logisticians at geographically dispersed organizations, including production controllers at depots, item managers (IMs) at national inventory control points (NICPs), and their retail system counterparts within material management centers (MMCs) and movement control centers (MCCs) at any level. To obtain full benefit of support resources, echelons should act in concert to provide coordinated support to the combat forces. Each repair and distribution execution decision—at division, corps, theater, and NICP levels—should maximize the probability of meeting specific weapon system availability goals and operating tempo requirements.

RBMS can respond to quickly changing repair and distribution workloads when shifts occur in weapon system availability goals or operating tempo requirements. It can automatically accept these shifts from a C^2 system designed to communicate weapon system



NOTE: Please see Abbreviations, p. xvii.

Fig. 1.1—Conceptual view of RBMS at different echelons

availability goals. It can also respond to special actions, such as losses of stocks caused by attack. In these cases, RBMS may reroute stocks from one unit to another, or it may route depot shipments to units that incur damages.

RBMS focuses on maximizing the likelihood of achieving unit-level weapon system availability goals over a short time horizon. The essence of its role is reflected in the two fundamental questions that it seeks to address: In view of operational needs, what is the ideal sequence in which to repair unserviceable assets? And, once repaired, how are those assets most advantageously distributed among units in the field? The basis for answering these questions is the DRIVE (Distribution and Repair In Variable Environments) algorithm, which takes into account various operational and logistical factors.[4] It estimates the level of demand for spare parts over a short (on the order of two or three weeks) planning horizon as a function of force composition, differential unit weapon system availability objectives and anticipated operating tempos, component removal rates, and so forth.[5] It also advocates the active use of advanced reporting mechanisms to track asset positions on a systemwide basis. By comparing the expected number of demands against on-hand assets and evaluating differences in light of weapon system availability goals, DRIVE obtains a measure of the marginal value of additional serviceable components to each combat unit.

Adapting RBMS to the New Environment

In a world of new threats and unpredictable operations, the structure as depicted in Fig. 1.1—one designed to support a standard, or "canonical," scenario, such as in Central Europe—is likely to be redesigned, and the role of RBMS along with it. These changes are still

[4]HQ USAF and HQ Air Force Logistics Command sponsored the work to develop DRIVE under a RAND study, "The Uncertainty Project." An operational prototype of the algorithm is being tested at the Ogden Air Logistics Center with the active participation of Air Force personnel. It is currently limited to F-16 peculiar aircraft avionics components repaired in the Avionics Integrated Shop and their SRUs that are repaired in the SRU Repair Shop and Microwave Shop. A RAND report describing DRIVE is being prepared.

[5]Ideally, priorities should change almost continuously; however, practical considerations often dictate a longer period between updates. The selection of an appropriate frequency should be governed by the circumstances under which RBMS is to operate. In peacetime, biweekly updating of repair priorities might provide a satisfactory level of responsiveness without unduly disrupting work flow; in wartime it would probably be insufficient to keep up with changing conditions.

embryonic, and we can only speculate; however, it is possible that in a contingency-oriented Army, units may deploy "lean and mean," with more of their support structure remaining in CONUS. To support a smaller force, the Army may move toward a support structure which includes special repair activity (SRA) units (single or multi-weapon system oriented) at depots or regional repair centers.

In such a new structure with more consolidated repair, support from a distance, and reliance on assured, rapid transportation, the structure of RBMS may be much simpler than that shown in the figure. Information from the field would flow directly back to CONUS, where intermediate- and depot-level repair would take place. Spares may be pushed to a theater or corps facility in the field, which would react to needs from the units on a near-instantaneous basis.

RBMS is designed to be most effective when it receives accurate, timely information and can anticipate needs across a planning horizon. The quality of data and the length of time for response may vary in different contingencies, possibly requiring some modifications in how RBMS is developed, fielded, and used.

The system will be affected to some extent by the fog of war, of course, especially as it receives inaccurate data from the field. Outdated or misleading estimates of weapon system needs and asset status may require more extensive integration of the RBMS network. For example, one solution may be a corps redirection function to receive incoming spares from the depot and, with more current information, to redirect the flow of parts to units whose needs are more apparent. We consider this refinement in our analyses of the demonstration prototypes.

Another form of this fog that afflicts logisticians is the apparent "disconnect" between the operators and the logistics community. Logisticians typically are not privy to commanders' plans; often they have to use guesswork to make any anticipatory moves. RBMS is designed to use anticipated operating tempos to determine optimized workloads; this ability will be threatened by any such disconnect. One possible solution may be to improve the support community's foreknowledge of operations without expecting specific detail. It should be possible to exploit RBMS's capabilities by giving it rough expectations of where more intense operations will occur, providing at least a relative sense of which units will be most in need. This concern is discussed in Sec. VI.

Another major concern for RBMS design is its ability to fit into a rapid response support system. In fast moving operations, the logistics system will have to respond quickly to rapidly changing needs.

The required planning horizons may be shorter than the two to three weeks mentioned above. Indeed, order and ship times (OST) may need to be on the order of one to two days for critical items. In such cases, a "push" policy may be less critical than quickly responding by "pull" methods to demands from the field. RBMS may still play a role in this fast response system, however. First, a mixed "push-pull" strategy may help the Army achieve reduced OSTs. RBMS, anticipating future operations, may "push" spares to an intermediate facility, such as a corps MMC, which could then respond rapidly to demands from engaged units.

RBMS can also enhance responsiveness by anticipating demands for repairs. In repair, one- or two-day turnaround is not likely to be achievable; some planning horizon will be necessary. Prioritization of repair workloads can help to support a rapidly responsive support structure by providing serviceable spares that can be sent out on short notice.

It should be emphasized that RBMS can be only one part of an overall system redesign. It cannot, by itself, optimize repairs and distributions or achieve weapon system availability goals. RBMS is, at root, little more than a computer algorithm. It is, however, part of an overall system predicated on weapon system management, including new information systems, policies and procedures, management authority, and divisions of responsibility between users and supporters. As the Army moves toward a goal of weapon system management, RBMS can play an important role in adding vital new management capabilities.

The Need for Evaluating RBMS

The final form of the RBMS network demands more analysis and development. Before that can occur, however, the value of the system as a whole must be demonstrated. Its value is based on three criteria:

- Feasibility—can data systems be designed or altered to feed RBMS?
- Effectiveness—will RBMS increase combat power at acceptable cost?
- Usability—can existing logistical organizations be changed to exploit RBMS capabilities?

The testing of RBMS on these measures of merit forms the substance of this report.

TESTING THE RBMS CONCEPT

Testing the RBMS concept calls for the extensive use of prototypes. Two phases of prototyping are identified: one for demonstration purposes and one for a hands-on, operational version to be exercised by Army personnel. Although it is less ambitious than an immediate move to full-scale development, this incremental approach offers several advantages. Most important, it provides a transition period during which potential users of RBMS can become better acquainted with its radically different ideas. By taking the time to study the underlying logic of both RBMS and responsive support in general, users may more readily accept its role in everyday management.

Another advantage of prototyping is the generation of preliminary feedback. For instance, prototype work may offer early insights into the potential payoffs of prioritizing repair and distribution actions. Alternatively, it may reveal system deficiencies or conflicts with existing policies and procedures. Feedback of this sort can provide useful direction for concurrent refinement of the RBMS concept and methodology.

The experience gained through prototyping will ease eventual implementation. Many of the obstacles that would otherwise impede full-scale development will be encountered and resolved within a controlled environment, thereby minimizing future disruption.

The prototypes focus upon high-cost, high-technology components for several reasons. First, these components are more likely to use the complex, multi-echelon support structures that RBMS was designed to address. Second, their cost and combat criticality make them leading candidates for inclusion in the asset tracking systems that RBMS exploits. Third, their low cube/weight factors encourage consideration of expedited shipping and handling, which are important aspects of responsive support. Finally, these components are often of the sort that share common test, measurement, and diagnostic equipment (TMDE).[6] This introduces an element of contention for maintenance resources and so invites the notion of prioritization.

[6]Examples include the Direct Support Electrical System Test Set (DSESTS), Electronic Quality Assurance Test Equipment (EQUATE), Thermal System Test Set (TSTS), and Army Depot Automatic Diagnostic System (ADADS).

Purposes of a Demonstration Prototype

A demonstration prototype is designed to show proof of concept through the development and exercise of theoretical analyses in a laboratory-style environment. For RBMS, we seek to expose the feasibility, effectiveness, and usability of the system by building an input database for computer analyses.

Feasibility implies both methodological suitability of the DRIVE algorithm and data availability. From the start of concept formulation, we have continually questioned whether DRIVE provides a sound representation of those portions of the Army's support structure to which RBMS applies. Thus, a major purpose of the demonstration prototype effort is to provide evidence on the suitability of the algorithm, especially in the newer environments. Also, can the RBMS database be built and run with the data available in existing Army data systems? Answering this question involves identifying sources of information, noting current limitations in accessing those data, and determining data quality. The intent is to develop a priority list of feeder systems that would need to be enhanced if RBMS were to be implemented in an operational environment.

The demonstration effort offers the opportunity to identify the combat payoffs or effectiveness associated with the implementation of RBMS. The relative merits of RBMS can be shown by contrasting its projected contributions to wartime sustainability with those of the current system. Further, the effort allows us to examine the flexibility of RBMS to different situations, particularly those involving uncertain, erroneous, or time-lagged input data.

Usability concerns the interaction between the user and the system, with particular regard to the policy and procedural implications of implementing RBMS in the real world. Feedback from potential users on the intent and design of RBMS helps identify: likely conflicts in policies, procedures, and work rules that users would experience; ways to change or waive interfering policies before proceeding to an operational prototype; current user performance measures and how RBMS would affect that measurement; recommendations for training given current user perspectives of the system; and modifications to make RBMS a more useful tool.

Choosing the Demonstration Prototypes

Three separate demonstration prototypes were chosen to examine the application of RBMS to the division, theater, and depot levels.

The work centers and items to represent were selected on the basis of four criteria.

First, the prototypes encompass a major portion of the repair workloads at key work centers, such as those at a wholesale depot or at an SRA. Items contend for maintenance resources, thus introducing the notion of prioritization and allowing different management policies to be studied. Second, the prototypes represent work centers that support different numbers of weapon systems, which allows us to isolate the effects of repair and distribution priorities on the sustainability of different types of weapon systems. Third, the prototypes coordinate the workload of items managed by geographically separated major subordinate commands (MSCs) to show the effect of RBMS on the availability of whole weapon systems. Fourth, to help determine under what circumstances RBMS is likely to have the greatest combat payoffs, the prototypes examine situations where the nature of the items and TMDE differ substantially.

Division-level Prototype. The first prototype encompasses the DSESTS workload as consolidated at the division's main support battalion (MSB).[7] Two high-tech weapon systems of seemingly comparable importance—the M1 Abrams tank and M2/3 Bradley fighting vehicle—depend significantly on the DSESTS for fault diagnosis of sophisticated and mission-critical LRUs in the fire control and turret subsystems. Armament, Munitions, and Chemical Command (AMCCOM) and Tank and Automotive Command (TACOM) manage these 21 items. Three divisions (a standard corps), consisting of 928 tanks and 1056 Bradleys, are modeled.

Theater-level Prototype. The focus of the second prototype is a contractor-run SRA dedicated exclusively to support the Target Acquisition Designation Sight/Pilot Night Vision Sensor (TADS/PNVS) system of the AH-64 Apache attack helicopter. The TADS/PNVS system consists of 26 very complex and highly advanced electronics and electro-optical LRUs that are an order of magnitude greater in cost than the DSESTS items. Aviation Systems Command (AVSCOM) manages these items. A three-corps theater of 198 Apaches is modeled.

[7]Current Army doctrine calls for DSESTS to be located at the brigade forward support battalion (FSB) with additional DSESTS support at the MSB. We have previously argued the greater effectiveness of consolidation of these resources rearward. As the analysis in Sec. IV suggests, these benefits would be even greater if RBMS were used at the MSB level, given the greater scope of coverage at the division level. See M. B. Berman et al., *Evaluating the Combat Payoff of Alternative Logistics Structures for High-Technology Subsystems*, The RAND Corporation, R-3673-A, October 1988.

Depot-level Prototype. The third prototype highlights the TSTS and EQUATE workloads of the electro-optical shop at Sacramento Army Depot (SAAD), which fixes night vision components on a wide range of weapon systems, including M1s and M2/3s. AMCCOM, Communications and Electronics Command (CECOM), and Missile Command (MICOM) manage the six LRUs and 30 SRUs involved. Three corps of nearly 14,000 weapon systems are modeled.

ORGANIZATION OF THIS REPORT

The remainder of this report discusses the feasibility, effectiveness, and usability of RBMS with regard to the demonstration prototypes. Section II introduces the reader to the methodology behind RBMS and the outputs it produces. The next three sections present results regarding RBMS's potential value for the Army. Section III describes the input data requirements and the availability of usable data in present Army data systems. Section IV gives evaluation results of the demonstration prototypes. Section V provides feedback from prospective users on the perceived usefulness of the system and suggestions for its improvement. Section VI gives future directions and suggests additional research.

II. RBMS METHODOLOGY

RBMS relies on the DRIVE model to interpret the input database and determine a priority sequence for repair and distribution actions during a given time horizon. This section describes how DRIVE works within RBMS and discusses the methodology used to measure its value with regard to the demonstration prototypes.

THE DRIVE MODEL

The DRIVE model analyzes the maintenance and supply process of two echelons: a rearward repair facility and the units it supports. Here the definition of a "unit" refers to a combat unit of fighting troops and weapon systems in conjunction with its own maintenance organization and supply support activity (SSA). For example, a unit of tanks might be defined as a brigade with its FSB or a division with its MSB; a unit of helicopters might reflect a combat air brigade and its aviation intermediate maintenance (AVIM) company. The two-echelon structure gives RBMS the flexibility to be used at a variety of organizations.

DRIVE suits the RBMS concept because it represents a different view of the goals of rearward repair than that of the current system. Emphasizing peacetime actions to support wartime readiness postures, it prioritizes both repair and distribution, always repairing next the asset that is most relevant to the current needs of the combat force and allocating it to the location where it will do the most good in achieving the overall specified weapon system availability goals. It views these goals across the full system, not individually by unit.

The logic underlying the model is intended to couple the rearward repair facility more closely to the combat force through the use of near-real-term asset status data and a dramatically shorter planning horizon than that of the current system. It sequences the repair and distribution actions in an attempt to make the most of constrained repair capacity. It accounts explicitly for demand uncertainty, force composition by unit, wartime operating tempos, and assembly relationships between reparable items. Moreover, it schedules the repair of SRUs one production period in advance to support LRU repair workload, thus incorporating a just-in-time repair parts inventory system; the intent is to reduce the shop flow times of many LRUs while significantly enhancing the efficiency of LRU repair.

In short, DRIVE is a model that guides execution. In contrast with models that help allocate stock levels, DRIVE actually assists logisticians by allocating serviceable assets.

Planning Horizon

Repair and distribution actions are scheduled across a short-term planning horizon that includes peacetime and wartime activities. The "length" of peacetime is defined by each unit's OST plus a nominal lead time (most likely an induction lead time). The length of wartime usually reflects the number of days units may have to be self-sustaining at the outbreak of hostilities. In total, the planning horizon should be no shorter than the time the system takes to complete a repair or distribution action.

DRIVE's objective is to maximize the probability that all units meet their weapon system availability goals as the planning horizon ends. Shorter horizons (and more current asset status) minimize its vulnerability to uncertainty in repair demands and poor estimates of operating tempo. Repair and distribution priorities for LRUs and SRUs then derive from those actions resulting in the greatest improvement in the weapon system availability objective per resource unit expended on repair and distribution (e.g., dollars or test time).

Inputs to DRIVE

The DRIVE model makes its priority decisions based on *operational* data describing the units and *logistics* data describing the components. Figure 2.1 illustrates the major inputs needed. Where and how to get this information is discussed in Sec. III.

Operational data include: force composition (who has weapon systems and how many they have); availability goals (the percentage of weapon systems desired to be fully mission capable at the end of the planning horizon); and operating tempos (activity levels for peacetime and wartime). Goals and operating tempos are specified by weapon system for each unit in the force posture. By design, RBMS accepts operational data that can change over time to reflect the relative importance of particular weapon systems or units.

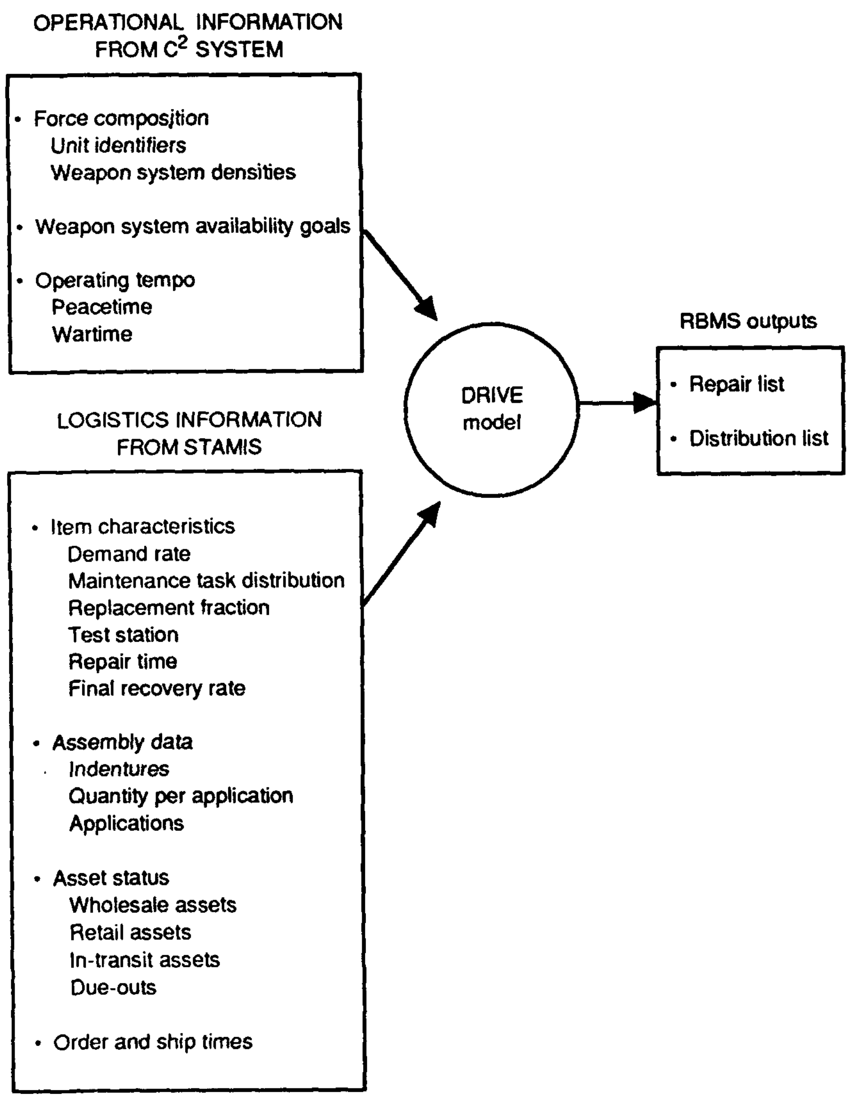


Fig. 2.1—Overview of RBMS inputs

Logistics data from standard Army management information systems (STAMIS) identify and describe the LRUs and SRUs being modeled. These data include: item characteristics (national stock number (NSN), demand rate, repair time, TMDE, etc.); assembly data (the relationship of items to each other and to the weapon systems); and asset status (the number and condition of assets at each location). Relating to both units and items are OSTs that help define the planning horizon.

The actual input database is structured around ten types of records, formats of which are provided in App. B.

RBMS REPORTS

The DRIVE model produces two kinds of reports for RBMS that can be put in various formats (electronic and hard copy). One is a sequenced list of repair actions for use by maintenance schedulers, repair shop foremen, and others concerned with the maintenance production schedule and ordering of parts needed for repair. The other is a sequenced list of recommended allocations of the serviceable assets emerging from repair for use by the item manager.

Repair List

The repair list provides a sequence of repairs for a given test station that maximizes the probability of achieving the weapon system availability objectives. Consider the sample shown in Fig. 2.2, which

THE TS SHOP

SEQ	NSN	ITEM DESCRIPTION	CUM IND	STD HRS	TOT HRS
1	1240-01-204-5765	Power control unit	1	2.9	3
2	1240-01-246-1873	Electronic unit	1	4.0	7
3	1240-01-246-1872	Image control unit	1	4.8	12
4	1240-01-204-5765	Power control unit	2	2.9	15
5	1240-01-204-5765	Power control unit	3	2.9	18
6	1240-01-246-1872	Image control unit	2	4.8	23
7	1240-01-264-2345	Thermal receiver unit	1	5.0	28
8	1240-01-264-2345	Thermal receiver unit	2	5.0	33
9	1240-01-264-2345	Thermal receiver unit	3	5.0	38
10	1240-01-264-2345	Thermal receiver unit	4	5.0	43
11	1240-01-264-2345	Thermal receiver unit	5	5.0	48
12	1240-01-204-5765	Power control unit	4	2.9	51

Fig. 2.2—Sample repair list

represents the TSTS workload. The power control unit consumes 2.9 hours on the TSTS during its repair. If 40 TSTS hours were available, RBMS recommends repairing the top nine items, including three power control units. The cumulative indicator shows the number of each of the four LRUs that should be repaired within the available hours.

The length of the repair list is intentionally long to provide backup repair options. If a shop has run out of a critical SRU that is holding up LRU repair, the shop manager can proceed to another item that will best meet the weapon system availability goals of the combat force. The list is meant as an aid to the user, who can override the suggested order based on information external to DRIVE. For example, batching items may be preferred in some situations to more economically meet the proposed schedule.

Distribution List

The distribution list prioritizes the allocation of serviceable assets to the units needing them most. Consider the sample shown in Fig. 2.3. Distributions are ranked by priority for each NSN. Flexibility of destination is built into the list. Items can be sent directly to the intended unit or to a higher echelon. In situations with a high variability in unit activity, the higher echelon can choose to hold the assets from engaged units or redirect assets elsewhere using better, more recent information.

As with the repair lists, the distribution list is meant as a tool. Users should deviate from it when they have pertinent reasons. For example, knowing an engaged unit has three battle-damaged items would be a valid reason for shipping three replacements instead of the number suggested by RBMS.

Other Possible Outputs

RBMS is not limited to producing the above lists. In addition, it can project quarterly and yearly forecasts of repair workloads using a modification to the DRIVE model. These longer-range forecasts can help logisticians examine the resources required to achieve alternative levels of weapon system availability. IMs might use this capabil-

			--- Send to ---		------- Intended Unit -------		
PRTY	NSN	Description	Div/Bde	Corps	DoDAAC	Loc	Name
1	1240-01-204-5765	Power control unit	2ARM	III	W4547A	Ft Hood	124 MSB
2			1MEC	VII	W55CSY	Ft Riley	701 MSB
3			155A	III	W35W7F	MS ARNG	155 BDE
4			2ARM	III	W4547A	Ft Hood	124 MSB
5			1MEC	VII	W55CSY	Ft Riley	701 MSB
6			1MEC	VII	W55CSY	Ft Riley	701 MSB
.							
.							
1	6110-01-217-2331	Switching regul (A1)	2ARM	III	W4547A	Ft Hood	124 MSB
2			2ACR	VII	WK4GDX	Nurnburg	002 ACR
3			2ARM	III	W4547A	Ft Hood	124 MSB
4			5MEC	VII	W42SU8	Ft Polk	705 MSB
5			2ACR	VII	WK4GDX	Nurnburg	002 ACR
.							
.							
1	6110-01-217-2334	Converter assy (A2)	3ARM	V	WK4F9R	Frankfrt	122 MSB
2			11AC	V	W81BAJ	Fulda	011 ACR
3			Depot	Depot	Depot	Depot	Depot

Fig. 2.3—Sample distribution list

ity to provide insights on the level of repair funding necessary to achieve specific levels of weapon system availability. Depots might use the estimates to help determine the number of repair parts needed to fix a given mix of LRUs and SRUs that are required to meet weapon system availability objectives.

EVALUATING RBMS

A second model, Dyna-METRIC,[1] provides the capability to evaluate the merit of RBMS and contrast it with the current system. The theory is that RBMS will do better in achieving weapon system availability goals because of its explicit focus on forward-looking operational goals, unlike the current system that bases repair and distribution priorities on historical data and such considerations as depot efficiency and unit stock levels.

Dyna-METRIC simulates the removal of items from weapon systems operating at various units and tracks the flow of serviceable and unserviceable assets through a multi-echelon repair and distribution system. Repair can be scheduled on a priority basis (repair the item hurting the most weapon systems) or a random basis (in essence, first come, first served (FCFS)); likewise, distribution can follow a priority scheme (satisfy the greatest need first) or a random scheme.

How Dyna-METRIC Works with DRIVE

Most often, Dyna-METRIC is run as a stand-alone system to evaluate the effect of alternative logistics support concepts on unit-level weapon system availability. However, it can also be linked electronically with DRIVE so that it may follow and evaluate its recommended priorities.

When directed by DRIVE, repair priority is given to the item nearest the top of the repair list for which an unserviceable asset exists in

[1] Dyna-METRIC has been imbedded in the Air Force Weapon System Management Information System (WSMIS). WSMIS provides weekly assessments to Air Force Wing commanders and is reported in the Air Force Unit Readiness Reporting System. For more information on WSMIS, see *WSMIS Sustainability Assessment Module (SAM), Functional Description* (Version 8.0), Dynamics Research Corporation, Andover, MA 01810. For more information on Dyna-METRIC, see R. J. Hillestad, *Dyna-METRIC: Dynamic Multi-Echelon Technique for Recoverable Item Control,* The RAND Corporation, R-2785-AF, July 1982; and K. E. Isaacson, P. M. Boren, C. L. Tsai, and R. A. Pyles, *Dyna-METRIC Version 4: Modeling Worldwide Logistics Support of Aircraft Components,* The RAND Corporation, R-3389-AF, May 1988.

the shop. In contrast, distribution priority depends upon the policy in effect. Under a standard "pull" policy where the central system allocates a serviceable asset to a unit only upon receipt of a requisition for one, priority is given to the unit nearest the top of the distribution list that has sent an unserviceable asset rearward for repair or replacement. Under a "push" policy where the central system has visibility of systemwide assets, thus enabling it to allocate serviceable assets forward without waiting for the unit to send in a requisition, DRIVE's priorities are followed exactly.

Running the Demonstration Prototypes

The demonstration prototypes, then, consist of input databases against which both models were run. We chose to look at repair and distribution actions at 15-day intervals for a 60-day scenario.[2] Each trial of the process required the following steps, which were repeated for each 15-day block of the scenario.

- Run DRIVE to build repair and distribution lists for the first 15 days.
- Run Dyna-METRIC for the first 15 days, using the lists output by DRIVE.
- Update the status information in the DRIVE database, using the pipeline information from Dyna-METRIC.
- Run DRIVE again for the next 15 days, using the updated information.
- Run Dyna-METRIC for the next 15 days, using the new lists.

For the simpler analyses, Dyna-METRIC was run in stand-alone mode to compare the priority repair and distribution scheduling of RBMS with the FCFS scheduling of the standard Army system.

MODELING ISSUES

Not surprisingly, we gained new insights into the role of a model and its requirements in RBMS during the process of exploring the demonstration prototypes. The DRIVE model could be enhanced to

[2]In practice, DRIVE should be run every day to determine appropriate distribution actions for serviceable assets, including those being returned to serviceable condition through repair. The DRIVE updates to guide repairs should be accomplished at reasonable intervals to keep repair relevant to combat unit needs.

work better with RBMS. The paragraphs below highlight the four most important modeling issues.

Units with Repair

The DRIVE algorithm does not deal accurately with units that have their own repair capability. When attempting to account for the expected contents of the unit-level repair pipeline, DRIVE treats each unit's repair queue as a set of serviceable LRUs, rather than as a source of potential SRU demands. This misrepresents the real world, where even under the most optimistic conditions, not all the LRUs in the queue would become serviceable—many would be shipped to a higher echelon for repair.

Overflow Policy

The DRIVE model does not consider the Army policy of "overflowing" to rearward repair the least important items in unit-level repair queues more than four days long. By ignoring this policy, DRIVE underestimates the number of unserviceable assets actually shipped out for repair and overestimates the SRUs needed at the unit for LRU repair, especially for periods of peak demand such as wartime. It also means that DRIVE misunderstands the mix of items shipped out for repair because it does not "see" the assets that automatically overflow, which will likely include normally unit-reparable assets that are easy to fix and have fewer broken SRUs. The whole issue of predicting future unit requirements and their rearward support needs to be re-examined in light of this Army policy.

Weapon System Configurations

More research needs to be done to determine how best to handle configuration differences in weapon systems among and within combat units, as well as differences among components. In particular, the DRIVE model requires some major extensions for it to incorporate interchangeable and substitutable stock numbers of components (as it stands, DRIVE uses master stock numbers only). The model must be enhanced to enable the particular configuration of stock numbers applicable to the weapon systems at a given unit to be reported on the repair and distribution lists.

Operating Tempos by Usage Basis

Weapon system activity plays a key role in DRIVE's calculation of component removals. Components can experience removals based on a variety of usage bases, among them operating hours, rounds fired, miles driven, and flying hours. However, DRIVE currently allows only one usage basis at a time. To better reflect actual removal processes and to align with the VISION Assessment System, DRIVE might be modified to accommodate multiple operating tempo types.

III. DATA ISSUES

RBMS inputs, which consist of operational data describing units and logistics data describing components, require a variety of sources and processing. The demonstration prototypes offered an opportunity to study the availability and quality of data found in STAMIS. This section addresses the suitability of likely STAMIS sources in meeting the particular data needs of RBMS.[1]

OPERATIONAL DATA

Information about unit operations allows RBMS to compute the expected support requirements of the combat force. Such information is often difficult to obtain because it requires a dynamic and forward-looking view of the combat force. The Army is developing systems like the Army Tactical Command and Control System (ATCCS) to enhance logistics C^2. Within ATCCS, the Maneuver Control System will provide operations plans and activity levels to support commanders' objectives, and the Combat Service Support Control System will provide information about the logistical aspects of operations planning.

The VISION C^2 concept paper will outline system modifications so that operational data may be collected and transmitted among the various decision echelons from Army commanders to logistics systems, including RBMS. Until automated sources of operational data are established, portions of the data will have to be obtained directly from the combat units and updated in the deliberate planning process.

Force Composition

The RBMS input database describes a rearward support activity (such as a depot repair facility, an SRA, or a supply point) and the units it supports. This allows RBMS to prioritize:

- Repair of components at the repair site;

[1]Appendix B describes the formal data elements and provides their location in the RBMS input database.

- Distribution of assets to field units from that site or supply point.

RBMS requires implicit knowledge of the logistics support structure for the weapon systems of interest for it to focus on maximizing unit-level weapon system availability.

In the demonstration prototypes, units comprise M1 tank divisions and their MSBs, and Apache battalions and their AVIM companies.

Unit Identifiers. By using the Department of Defense Activity Address Code (DODAAC) to identify units, RBMS provides useful shipping addresses for distribution of assets. DODAACs should reflect the SSAs to which serviceable assets are routinely shipped. It is possible that units will be not be uniquely identified by DODAAC because they may share the same supply point. To distinguish units on the output reports, the RBMS input database allows for a seven-character unit name, four-character division name, and two-character corps name.

RBMS will draw upon various types of STAMIS that do not always identify units the same way. Supply and transportation data systems use DODAACs, whereas maintenance data systems use unit identifier codes (UICs). AMC's Systems Integration and Management Activity (SIMA) maintains a DODAAC-UIC cross-reference file that should prove helpful to RBMS.

In an ideal world, a unit's DODAAC would imply its logistics support structure. That is, the support hierarchy of a particular weapon system and unit could be determined from the unit's DODAAC. Computer files linking the logistics support hierarchies would need to be established and maintained to enhance RBMS's responsiveness to likely changes in these hierarchies during wartime. This could be a function of a logistics C^2 system.

In the demonstration prototype databases, units were identified by the DODAACs of the locations showing assets on the component's NSN Master Data Record (NSNMDR).

Weapon System Densities. The number of weapon systems at each unit helps RBMS differentiate support among specific units and weapon systems. For major end items, the Continuing Balance System–Expanded (CBS–X) collects the number in use by Army activities worldwide from property books and reports them by UIC on a monthly basis. For aviation systems, the Army Gold Book[2] lists, by

[2]Army Aircraft Inventory Status and Flying Time, prepared monthly by the readiness division of AMC's Materiel Readiness Support Activity (MRSA).

unit, the number of aircraft owned and hours flown during a particular month.

Issues of concern are twofold: keeping an accurate inventory and the classification level of density information. The former means being able to transmit to RBMS information about new units (such as task forces drawn from different units for contingency operations) as well as changes within existing units. The latter concerns the classified status of files that display densities rolled to the corps level and above, such as CBS–X. When implemented, RBMS may have to be run in a secure environment.

The prototypes were kept unclassified by using the 1990 authorized levels provided by the Combined Arms Support Command (CASCOM) for tank densities and the Martin Marietta Corporation (who operates the TADS/PNVS SRAs) for Apache densities.

Weapon System Availability Goals

Unit- and weapon-specific availability goals give RBMS the ability to stress the importance of one unit or weapon system over another, which is crucial if RBMS is to make sound decisions. Current doctrine[3] states general readiness goals of 90 percent for ground systems and 75 percent for aviation systems, which were used in the prototypes. What is missing are sustainability goals and goals that vary by unit.

Ideally, combat commanders should provide availability goals. However, it is important to consider the overall picture when determining appropriate unit goals, especially during a time of conflict. Perhaps, then, higher-level commanders—division commanders for brigades, corps commanders for divisions, and theater commanders for corps—should provide the ultimate guidance.

Operating Tempo

Operating tempos, the basis against which item demands are computed, help RBMS forecast item requirements at the unit level. They are separately specified in the database for peacetime and wartime as the monthly usage per weapon system for each unit. Usage may be measured in a number of ways: flying hours, operating hours, engine hours, miles traveled, rounds fired, sorties, and the like. The appro-

[3]As defined in Army Regulation AR 220-1, Unit Status Reporting.

priate usage basis should reflect the items modeled. Anticipated combat postures, such as defend, delay, and attack, should also be considered when establishing the expected operating tempos.

It is important to point out that precise estimates of activity levels are not needed for RBMS to make sound decisions; significant relative variations in activity among the units can be equally useful. For example, recognizing that units engaged in contingencies are switching from low to high operating tempos can be enough for RBMS to work in the right direction. The intent is to swing support to engaged units in an anticipatory fashion so that the system can respond quickly to unexpected demands. This "proactive" decisionmaking is particularly useful for commanders, who need to react to dramatic shifts in operating tempos.

The demonstration prototypes examined wartime situations only. Each of their operating tempos were derived from a high-intensity, nonlinear conflict based on the Central European Scenario developed by Concepts Analysis Agency (CAA).

Peacetime Operating Tempo. Monthly activity levels in peacetime can be based on known planned usage (e.g., for an impending field exercise), budgeted levels, or even historical usage. Undoubtedly, actual activity will vary from the estimates fed into RBMS. RBMS's short planning horizon allows the system the flexibility of making adjustments in a timely manner.

The Army Oil Analysis Program (AOAP) is a good source of ongoing usage for aircraft, combat vehicles, and selected tactical vehicles. This program is managed by MRSA as part of a DoD-wide effort to detect impending item failures through periodic analysis of oil samples. Important entries on the AOAP reporting form include the hours since the last oil change and the UIC. Oil samples are submitted monthly for aircraft and combat vehicles and bimonthly otherwise. Usage for other smaller systems is reported once a year to The Army Maintenance Management System (TAMMS). MRSA combines the data from the AOAP and TAMMS to produce the TAMMS Equipment Data Base (TEDB). Though an excellent source for usage of "oil-washed" systems, the TEDB does not collect the usage of other systems such as radios and generators; sources of their operating tempos must be identified. An additional source for aviation systems is the Gold Book.

Wartime Operating Tempo. CAA and the Training and Doctrine Command are two of many organizations who develop wartime planning scenarios. To facilitate predicting wartime usage and coordinating commanders' operations plans (and availability goals) requires a C^2 system such as ATCCS or the VISION C^2 system.

LOGISTICS DATA

Information relating to the items themselves, such as NSN, nomenclature, and application data, can be found in several STAMIS. The Commodity Command Standard System (CCSS) contains databases oriented to wholesale supply management support. Particularly useful to RBMS are the NSNMDR, which carries 27 sectors of information about each NSN, and the Provisioning Master Record (PMR), which establishes weapon system configuration and maintenance engineering data for provisioning.

Most logistics data can be considered static and rather easy to keep accurate. The main exception is asset status, an ever-changing part of the database that must be tracked constantly and accurately for RBMS to work.

Item Characteristics

The LRUs and SRUs considered in the prototypes were high-tech electronic and electro-optical items. They are identified by NSN and nomenclature as stated in the Army Master Data File (AMDF). Other characteristics help define the items' demand on repair resources; this demand, in turn, partially shapes the units' ability to meet their availability goals.

Demand Rate. An underlying assumption of RBMS is that item demands occur in proportion to weapon system activity. We realize that demands cannot be anticipated perfectly; factors such as operating hours or rounds fired are at best flawed predictors. However, such imperfect information can give a rough indication of anticipated demand levels. It need not even be in terms of hours or rounds; substitutes could include days in combat postures, if that could be used to estimate the likely number of demands. Clearly, though, the more accurate such data can be, the more effective RBMS will be.

Aside from aviation, which tracks demands per flying hour, the demands associated with ground systems do not reflect operating tempo. Rather, they are reported as demands per time period. The demand rate RBMS requires can be derived from the mean units between replacement (MUBR), defined as the usage of an item before it is removed and requires a replacement from the supply system. The maintenance directorates at the MSCs create MUBR rates for items in their candidate item files, used to develop the combat prescribed load list/authorized stockage list (PLL/ASL). The same procedure could also be applied to other items to produce their demand rates. The MSCs use four sources for MUBR rates in the following preferred order.

- Field Exercise Data Collection (FEDC), a program managed by AMC's Army Materiel Systems Analysis Activity (AMSAA) that collects maintenance data on equipment in select battalions over a two-week wartime scenario.
- Sample Data Collection (SDC), a program managed by MRSA that provides maintenance and logistics data on select types of equipment at select using units and their support units.
- Central Demand Data Base (CDDB), a file managed by AMC's Logistics Control Activity (LCA) that captures organization-level repair parts demand histories.
- Engineering estimates in the PMR reported in CCSS.

For the tank and Bradley items in the demonstration prototypes, demand rates were calculated from seven years of SDC information. For the TADS/PNVS items, demand rates were provided by Martin Marietta data systems.

Maintenance Task Distribution (MTD). The MTD reflects the percentage of unserviceable items that are evacuated to the supporting (rearward) facility because the unit does not have the capability or the time to repair them. For RBMS, the MTD helps determine the amount of expected workload at the support facility being modeled.

In Army data systems, separate MTDs show the proportion of the item's maintenance performed by organizational units, intermediate-level direct and general support units, depots, and contractors. MTDs are carried in the PMR, but they are only engineering estimates that are rarely, if ever, updated to reflect actual activity.

An SLA initiative called Usage-Based Requirements Determination (UBRD) seeks to update the PMRs with actual data drawn from various sources, among them FEDC and SDC. SDC was the source of MTDs for the demonstration prototypes.

Replacement Fraction. SRUs generate demands at the supporting facility in two ways. They can be determined unserviceable at the unit and shipped back for repair, or they can be determined unserviceable at the supporting facility as part of a broken LRU shipped there for repair. The MTD captures demands of the first case, and the replacement fraction captures demands of the second.

Standard Depot System (SDS) mortality files report the parts consumed in depot repair. An SRU's replacement fraction, defined as the proportion of LRUs sent back for repair on which the SRU is found to be broken, could be calculated from these files by dividing the number of SRUs consumed by the number of parent LRUs seen at the shop.

Test Station. Test stations describe the work center at the supporting facility in terms of resource or capacity constraints for which RBMS prioritizes repair. They usually depict TMDE (as in the demonstration prototypes) but can also refer to such things as personnel or dollars.

To help RBMS users determine appropriate test stations, a lookup table is needed that cross-references such things as item NSNs, TMDE, and required manpower, similar to that of the Army's maintenance allocation charts for weapon systems. For depots, the Capability Engineering Data Reporting System (CEDRS) provides some of this information to Depot Systems Command (DESCOM) for use in planning depot workloads.

Repair Time. Because repair prioritization must consider the expenditure of constrained repair resources, RBMS requires the standard number of hours each item uses the resources to complete repair (including multiple cycles). Some depot shops currently keep their own in-house records of their repairs, but they do not report to a formal data system. Lower echelon shops do not appear to formally track their repairs. Sources of repair times for the prototype items were the electro-optical shop at SAAD, Martin Marietta, and the SDC.

A good, more standard source for the future appears to be the completed work orders and repair parts information from the Standard Army Maintenance System (SAMS), which MRSA uses to build and maintain the Work Order Logistics File (WOLF). The WOLF can trace the entire intermediate-level repair process on an NSN basis, including the time an item spends awaiting pickup, awaiting shop, in shop, and awaiting parts. The repair time required by RBMS would be part of the in-shop time. Because only hands-on man-hours can be distinguished from other in-shop processes, they can be used to approximate on-stand test times. Ideally, SAMS could be modified to provide more detail about in-shop processes, or the current informal tracking by repair shops should be formalized and reported.

Final Recovery Rate. The final recovery rate indicates the percentage of unserviceable items that the supporting facility repairs and makes serviceable. It is reported in the NSNMDR, which we used in the prototypes. The supporting facility should verify the NSNMDR rate against its own records.

Assembly Data

Assembly data describe the physical makeup of each unit's weapon systems. Indentures show parent-child relationships among items. Applications describe the percentage of weapon systems configured for particular component NSNs. Knowing configuration differences among units is vital if RBMS is to make sound distribution decisions. The point is to avoid sending an item to a unit that cannot use it.

Indentures. Information that relates LRUs to weapon systems and SRUs to LRUs exists in standard data systems but in formats cumbersome to use. The PMR files and NSNMDR provide encoded family trees that identify items by codes other than NSN; they must be processed several times to determine the NSN of the item's parent. Additional drawbacks of the PMR files are their nonstandardness (each MSC builds its own file) and questionable accuracy (the information is based on engineering estimates).

A family tree would prove helpful not only to RBMS users, but to those in the MSCs who require configuration information and consumption data. For items that have repair parts, a usable indenture file might be built from several sources of consumption data.

- SAMS reports the parts used in intermediate-level repair to the WOLF.
- SDS mortality files report the parts consumed in depot repair.
- SDC captures consumption data from all retail levels of repair.

Part of the UBRD effort is to build a corporate PMR for a weapon system that carries up-to-date configurations. Used in conjunction with SIMA's Major Item System Maps, UBRD will be able to provide the family-tree structure that RBMS needs.

For the prototypes, indentures and next higher assemblies were determined as we selected the items to model. The repair shop at SAAD and Martin Marietta confirmed these data as appropriate. The division-level prototype considered only LRUs, so relating LRUs to SRUs was not a problem.

Quantity Per Application (QPA). An LRU's QPA is the quantity installed on the weapon system as a whole, not on a subsystem. For SRUs, QPA refers to the quantity per LRU (the quantity per weapon system is, thus, inferred). The NSNMDR reports QPA as quantity per next higher assembly in a usually unused sector (19/02). Better sources of QPA include the item manager, UBRD, SAMS, and SDC. For the prototypes, QPAs came from IMs and Martin Marietta.

Applications. Application fractions specify the proportion of each type of weapon system on which the LRU is installed at each unit. The problem is compounded for SRUs, whose application fractions apply to the parent LRU for which there may be more than one interchangeable and substitutable (I&S) NSN. In the prototypes, configuration differences in weapon systems were not considered.

The AMDF contains I&S cross-reference data by NSN, including other I&S stock numbers, its subgroup master, and preferred order of use. AMC's Catalog Data Activity (CDA) maintains, updates, and reissues the AMDF monthly. Though valuable, the AMDF lacks part of the information RBMS needs—it does not relate the NSNs to the configuration of weapon systems at particular units. A step in the right direction is MRSA's end item application file, which verifies the application of repair parts to end item.

Eventually the Standard Army Retail Supply System (SARSS) should provide the information necessary to determine each unit's configuration of weapon systems. Designed to integrate retail supply from unit level through theater level, SARSS uses I&S logic to track assets and will be extended to Class VII supplies (major end items).

Asset Status

Asset visibility is a critical element of the RBMS concept. The current status of systemwide assets helps RBMS determine the sequence of repairs and distributions that will maximize weapon system availability.

Wholesale Assets. RBMS extends the usual definition of a "wholesale" asset to include any issuable stock that is not assigned to a unit. Typical locations that hold wholesale assets are depots, theater storage sites, MMCs, and contractor repair facilities. Excluded are assets at these locations that are earmarked or restricted for issue to specified requirements as indicated by ownership purpose code.

The RBMS input database calls for each item's wholesale asset positions within three condition codes: serviceables (code A), unserviceables (code F), and items in maintenance (code M). The NSNMDR (sector 5) reports on-hand quantities to that level of detail, stratifying assets by location code, ownership purpose code, and condition code. Sector 5 captures depot reporting of receipts and shipments of assets to the CCSS as they occur. These data, used and trusted by MSC staff, are considered valid and accurate.

Retail Assets. These assets consist of stocks already assigned to a unit that either are in serviceable condition or are in maintenance. (The assumption is that unserviceables are not sitting on the shelf at the unit, but have been shipped out for repair or are in repair at the unit.)

For the most part, existing STAMIS do not track retail assets. Only CCSS carries the status of items coded for the Selected Item Management System–Expanded (SIMS–X) in the NSNMDR (sector 7). With few exceptions, only Class IX automatic return items (those in a critical stock position) that are depot/SRA-reparable and have annual demands costing over $50,000 are eligible for SIMS–X reporting.

SIMS–X data generally are not used by the MSCs because there appear to be significant errors in reporting. For example, on-hand and due-in assets do not reconcile with requisition objectives and due-out assets; due-in assets do not reconcile with active requisitions in LCA files. Further investigation by SIMA is ongoing to clean up this sector and validate the information reported there.

In-Transit Assets. Two LCA databases—the Logistics Intelligence File (LIF) and Materiel Returns Data Base (MRDB)—identify assets that are in transit to and from supported echelons. Currently field units have the ability to interrogate these files through modem. For RBMS, these files should be synchronized and electronically connected with the data systems that report on-hand assets, namely CCSS.

Due-Outs. To sequence distribution actions, RBMS captures information about the weapon systems with the most critical need: those with deadlining items, or holes. Holes are represented in the input database as the number of LRUs at the unit that are due out to weapon systems. At the SRU level, the database enumerates the SRUs for which LRUs in maintenance are not mission capable supply (NMCS)—in other words, LRUs in condition code G status.

Existing sources do not appear to have the right information about due-outs. For example, the WOLF reflects recent history rather than ongoing status, while SIMS–X does not distinguish between holes in weapon systems and holes in unit PLLs.

Under AMC development is the Army Materiel Status System (AMSS), a cross-commodity real-time readiness reporting system that will specify the items deadlining weapon systems. Feeding off information in SAMS, AMSS should be the source of due-outs for RBMS.

Sources Used for the Demonstration Prototypes. The three prototypes tested different sources of wholesale and retail asset status. Authorized combat ASL/PLL quantities were used in the division-level prototype. Martin Marietta corporate data systems provided actual on-hand quantities for the SRA prototype. SIMS–X was the source of asset status for the depot-level prototype. In-transit status was excluded from the prototypes; all assets were considered in place at the start of the scenario. Only the SRA prototype had due-out status (as reported by Martin Marietta).

Sources of the Future. SLA has begun developing an automated Total Asset Visibility (TAV) management information system that will ultimately provide near real-time visibility of Army assets by location, quantity, and condition. TAV seeks to integrate wholesale and retail supply systems to support the move toward a single seamless supply system that will aid weapon system management. Some of the input systems are CCSS, SDS, and SARSS.

SLA also sponsors the Objective Supply Capability (OSC) initiative, whose purpose is to reduce OST and customer wait time by providing the means to achieve near real-time processing of requisitions. OSC relies on asset balance files from retail SSAs to allow cross-leveling of excess stocks at an installation.

OSC, TAV, and RBMS are planned to share information and support one another.

Order and Ship Times

RBMS bases the peacetime portion of the planning horizon on a nominal lead time and unit-specific OSTs. The LIF contains the information from which to derive OSTs—it tracks the flow of requisitions from user to source of supply and back by NSN. For the demonstration prototypes, we did not use the LIF but determined OSTs based on prior research as described in Sec. IV.

SUMMARY OF DATA ISSUES

RBMS's data requirements are being addressed, in part, by the recent efforts to enhance existing Army data systems and build new ones. The hard-to-get operational data need to be pursued by advocating changes to ATCCS, while logistics data will profit from advances being made in TAV, UBRD, OSC, AMSS, SARSS, and SAMS. Existing data systems could provide the bulk of the information RBMS requires. The NSNMDR, AMDF, and SDC collect many of the item characteristics already.

As systems come on line, they must be able to be integrated and linked electronically. MRSA is pursuing the Army Data Validation and Netting Capability Establishment (ADVANCE), an automated logistics networking system that will tie in key elements of both wholesale and retail systems such as SDS, CDDB, SAMS, SDC, FEDC, and AOAP. One of the reasons for ADVANCE is to resolve standard information problems, including the problems of files in different formats, fragmented data, files sorted on different values, and data that are difficult to correlate. ADVANCE is the type of system likely to be a good source of integrated data for RBMS. Further research must be done on how RBMS would access and download data.

IV. EVALUATION OF THE DEMONSTRATION PROTOTYPES

A major reason for developing the demonstration prototypes was to identify the combat payoffs of using RBMS. Specifically, we sought to measure the increase in weapon system availability gained by following RBMS policies for scheduling repairs and distributing serviceable assets.

ASSUMPTIONS FOR ANALYSIS

The Standard System

There is no standardized method for performing prioritized repair in the current system, either in the retail or wholesale systems. Repair facilities in units, as well as depot programmers, may respond to demands from the field or may gather information in an ad hoc fashion as to what priorities are, but such efforts are purely voluntary. Typically, the "prioritizing" system to be used in wartime is FCFS. Depots operate in peacetime under a different system, by employing procurement work directives, which set yearly production goals based on quarterly inductions for each LRU or SRU. Unserviceable assets are inducted for repair only at the beginning of each quarter.

Standard distribution systems would face similar problems in a wartime environment. Distribution of serviceable assets to units is based on a standard Army prioritizing system that depends on such factors as unit location, need to support potential combat operations in the future, and importance of the component for supporting combat. The system is not sensitive to differential unit goals among units already engaged in combat. In these cases, it is likely that the standard system would also be forced into an FCFS prioritization method, except, again, for extraordinary ad hoc interventions.

In the evaluation of the demonstration prototypes, we seek to compare the combat benefits of an RBMS-based prioritization system against that standard system likely to be widespread in wartime. To best capture the likely performance of such a standard system, this analysis assumes that all repairs and distribution actions are based on a first come, first served logic.

Scenario

The three prototypes used the same scenario—a high-intensity, nonlinear conflict that has some characteristics associated with mid-level contingency operations. The scenario was derived from CAA's Central European scenario in the P90E case. Although a European war is less likely to be representative of the kinds of fighting the Army may have to do in the future, the scenario is useful from a logistics point of view:

- It is typical of the fluid, nonlinear combat the Army is trained to fight;
- Many scenarios will be characterized by the same high intensity of operations;
- The scenario looks at varying deployments—from three divisions up to three corps—also characteristic of future operations;
- The scenario is characterized by greatly varying demands among the employed units at different times, likely to be a factor in most contingencies.

The analysis is conservative because we made a simplifying assumption that all weapon systems and spare LRUs and SRUs were operational on the first day of the scenario, which we limited to 60 days of wartime. We believe additional benefits from RBMS would emerge if peacetime and transition-to-wartime operations were also supported by RBMS.

Resource Availability and Pipeline Lengths

Test-stand availability is a function of location and need for movement. For TMDE located in theater, we assumed a two-shift availability of 16 hours a day; for CONUS-based resources, 18 hours a day.

Likewise, OSTs and retrograde pipeline times depend on the distance between the repair activity and unit supported. We assumed five days for the division-level prototype, eight days for the theater-level prototype, and nine days for the depot-level prototype. While these times are more rapid than standard over-the-ocean transportation times, as we have argued before, solving the problem of transportation to and from CONUS repair facilities is critical if such facilities are to become effective players in combat support.[1]

ANALYSIS OF THE DIVISION-LEVEL PROTOTYPE

The first prototype examines the application of RBMS to division-level repairs; it focuses on DSESTS workload as consolidated at three divisional MSBs. Two major weapon systems, M1 tanks and M2 Bradleys, contend for DSESTS resources. We examined a 60-day European scenario employing 928 M1 tanks and 1056 M2/3 Bradley fighting vehicles in three divisions.

The analysis focuses on capturing the effect of constraint on the 18 DSESTS located either in the division or the corps rear. This prototype raises several issues for analysis, among them:

- How to identify and rectify imbalances in stated requirements across weapon systems sharing the same support;
- How best to employ a future fielded integrated family of test equipment (IFTE) system;
- How best to achieve reductions in needed support resources through consolidation and through better management of the remaining support elements.

Weapon System Contention for Shared TMDE Resources

A major issue of this prototype was that of weapon system contention for shared, limited resources. The distribution of scarce resources is, of course, a critical matter for any commander to face in wartime—for example, which units will get preference for petroleum, oil, and lubricants (POL) and ammunition, and where should the highest priority go for scarce air cover? However, the allocation of scarce test time on shared repair resources is a new issue the Army is facing, one that will grow all the more important in the future.

As previous research has shown,[2] electronic TMDE is a critical resource for weapon system readiness and sustainability because it di-

[1] See Berman et al., 1988.

[2] Berman et al., 1988; also see William G. Wild, *Supporting Combined-Arms Combat Capability with Shared Electronic Maintenance Facilities*, The RAND Corporation, R-3793-A, May 1990.

agnoses faults in components that have proved to be important drivers of availability of tanks, Bradleys, helicopters, and other weapon systems. Yet, without information and a clear understanding of priorities, skewed decisions may be made.

Figure 4.1 demonstrates this with regard to the first prototype. It shows the percentage of M1 and M2 weapon systems not fully mission capable (NFMC) over the scenario for the items modeled.[3] Differentiated are the performances of a standard system based on FCFS policies for repair and distribution versus that guided by RBMS operating at the MSB and division MMC.

Two features are worth noting. The first is the standard system's loss of M1 availability, as compared with the RBMS results. By day 60, 25 percent of the M1s are unavailable for combat directly as a result of these LRUs. Meanwhile, M2 availability suffers no dropoff in

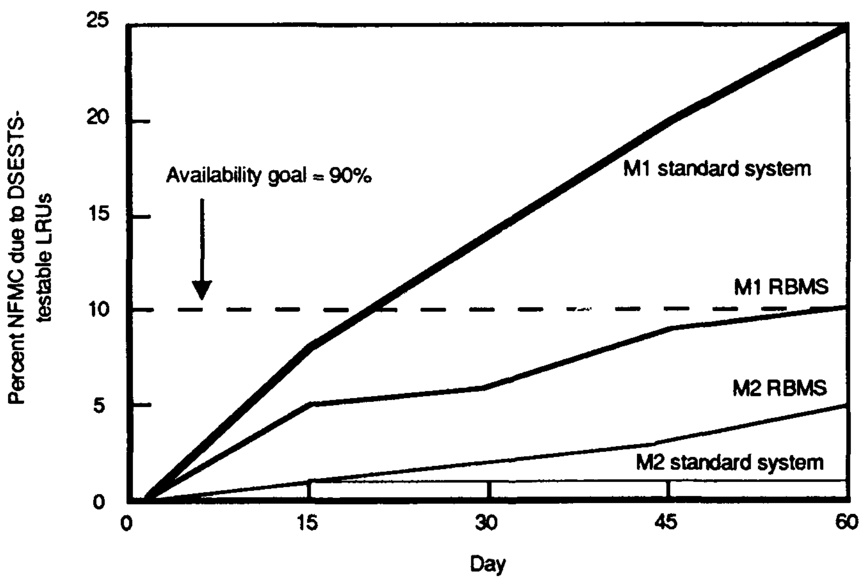


Fig. 4.1—Effect of RBMS on weapon system availability

[3]In this case, and all the other prototypes, we do not present total weapon system availability. We show instead decrements of mission-capable status due only to the components modeled. Total weapon system availability will be a function not only of these components but other LRUs and SRUs as well—not to mention availability of POL, munitions, and crews. A completely fleshed-out RBMS will have to consider not only this relatively small slice of the weapon, but also a larger set of resources.

the standard system—it stays above 95 percent for the entire scenario.

The reason for this discrepancy becomes clear when we consider resource imbalances. According to calculated Army requirements, larger pools of spares are likely to be available to support the M2 than the M1.[4] Thus, M2 forces will need to rely less on repair to achieve their availability goals. This is not the case for the M1, for which spare LRUs are relatively scarce. The standard system, however, may not recognize this discrepancy.

Without a systemwide view of all resources necessary and available to support the forces, the standard system may tend to make incorrect decisions (i.e., decisions based on the number of reparables awaiting repair). This is the case here, where a large slice of available DSESTS test time is devoted to broken M2 LRUs, despite the abundance of M2 spares, while broken M1 LRUs, for which no spares are available, wait their turn in the queue.

Given the nature of M1/M2 usage (they often fight jointly), it is unclear that high availability for M2s in the standard system has much utility to the combat commander. It may be, in fact, that the higher M2 availability is effectively no greater than that of the M1, since

[4]In this analysis, we used stated Army requirements for M1 and M2/3 LRUs in ASLs and war reserves. The way requirements are currently computed, the M2/3 stock is much more favored. The removal rate of M1 DSESTS-testable LRUs is twice as great as those from the M2/3, and their demand for test equipment time is four times greater. Yet it appears the Army intends to buy substantially more LRUs to support the M2/3 than to support the M1. Requirements for this three-division slice of M1s and M2/3s show some 1023 Bradley items to be purchased at a cost of $8.21 million versus 498 M1 LRU spares at $4.72 million. Army policy tends toward buyout of lower price components as far as possible, and these M2/3 items are indeed cheaper on a per-item basis. (The average cost of an M2/3 LRU testable on the DSESTS is $4617 versus $7170 for the M1; the figures are even starker when weighted by removal rate: $22,179 per 1000 hours of operation for the M2/3 versus $58,809 per 1000 hours for the M1.) The difference in stock buy policy between the two weapons is understated by the tendency to buy greater numbers of the cheaper LRUs even within the set of M1 LRUs; the most expensive M1 LRUs (which also tend to be ones with high removal rates, test times, and reliance on rearward repair) are underbought all the more.

This is not to argue that the Army is following a foolish policy (quite the opposite in fact), only that the Army has thus far adopted only half of a correct policy. Test and repair is cheaper than stock buyout; it is more cost-effective to repair an expensive LRU than simply to buy its replacement. Along the same lines, it is wiser to offload test equipment by buying extra supplies of cheaper LRUs, and so not allow them to absorb test equipment time better devoted to repair of the scarcer high-cost LRUs. The Army has begun this course with greater stock buys of the cheaper Bradley LRUs; however, it also needs to determine when the more costly M1 components should be given priority in the queue waiting for DSESTS time. This is precisely what RBMS is built to do, and what this prototype is attempting to illustrate.

M2s without M1 support cannot operate as the Army intends them to fight.

The second point of the figure is the balance RBMS achieves. The goal is to achieve a minimum of 90 percent fully mission capable (FMC) weapon systems across the board.[5] RBMS not only brings the two weapon systems into better balance, but it does so at or better than the 90 percent goal by more effectively allocating resources to compensate for shortages. Basically it starves the M2 LRUs of DSESTS test time, devotes more of the time to M1 parts, and thereby achieves substantial gains in M1 availability. There would be at most a small cost to pay in M2 availability lost, since RBMS tries to bring the two weapon systems into greater availability balance.

Implications for a New Force Structure

In terms of showing the effect of resource imbalances, this prototype deals with what might fairly be considered a crude and simple case: it involves only two types of weapon systems and few LRUs; the problem is immediately obvious—too much stock for one system, not enough for the other; and the scale—repair at just three divisions—is fairly small.

However, this simplicity highlights a serious problem future systems will face. The Army is developing new types of test equipment, such as the IFTE, that will be able to support many weapon systems and potentially thousands of LRUs. In addition, the Army is considering new doctrine for supporting electronic systems through the creation of units like the electronics maintenance company (EMC) that might be located anywhere in division, in corps, or even in echelons above corps (EAC). The combination of these two new developments opens up the possibility of achieving major cost savings through economies of scale.

Yet, as the previous analysis suggested, without a new concept for managing these tools and units, the savings may be lost. Combat effectiveness may be undermined by just the kind of resource imbalances this prototype makes so clear. Applying RBMS to the IFTE and the EMC could help the Army best exploit the new resources, for the benefits shown in the simple case described above can be extended to

[5]Of course, goals may differ among weapon systems, between units, or over time—we deal with those possibilities later in this section.

the far more challenging environment that supporting more than 20 weapon systems through one test station would create.

The Role of RBMS in a Resource-Lean Environment

One major benefit this more sophisticated management system offers is potential cost savings. Recent events have clearly shown that, regardless of the threat, the Army will have to make do with less. The Army must live in a world of sharply reduced resources while maintaining as high a level of combat effectiveness as possible. Systems like RBMS can help the Army adapt to a tightly constrained world. In the paragraphs that follow, we look at a variety of strategies for reducing resources while using RBMS to maintain combat power.

The Army can pursue various strategies for reducing costs, as shown in Fig. 4.2. The strategies shown here focus on just the resources for supporting the DSESTS LRUs—estimated at $52 million—for one corps of M1 and M2 weapon systems in an extended

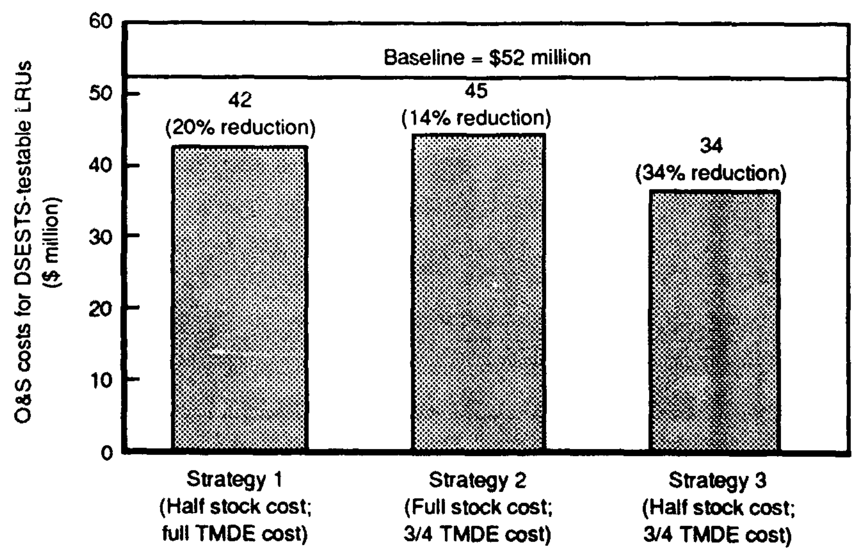


Fig. 4.2—Strategies for reducing O&S costs of DSESTS LRUs

scenario.[6] The figure shows three of many possibilities for reducing operation and support (O&S) costs: Strategy 1 cuts half of the stock cost (all from M2 stocks); Strategy 2 cuts 25 percent of TMDE and related personnel; Strategy 3 combines both the stock and TMDE reductions. The cost saving realized would range from 14 to 34 percent of the total for supporting these LRUs.

Cutting resources, however, may lead to losses in capability. Figures 4.3–4.5 demonstrate the potential risk involved in the three strategies for resource reductions and the value RBMS offers. Figure 4.3, which examines Strategy 1 (reduced M2 stock), shows the availability of M1s and M2s on day 45 for three cases: a fully resourced standard system; a reduced-stock standard system; and a reduced-stock system with RBMS. The standard system shows no penalty associated with reducing stock simply because the stock was in excess to begin with; however, it fails in terms of balancing the

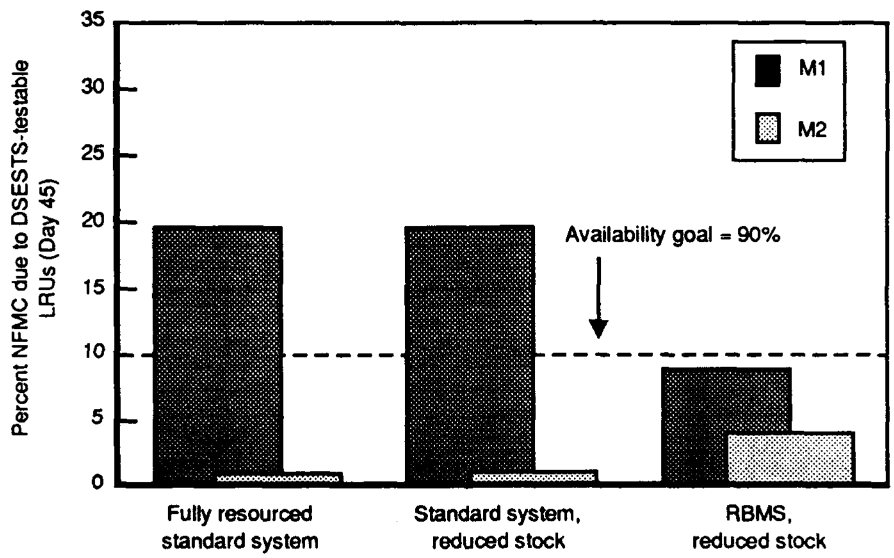


Fig. 4.3—Effect of O&S Strategy 1—20 percent cost savings through reduced stock—on M1/M2 availability

[6]Costs include all spares, test stands, and support costs for operating the test stands over a 20-year life cycle.

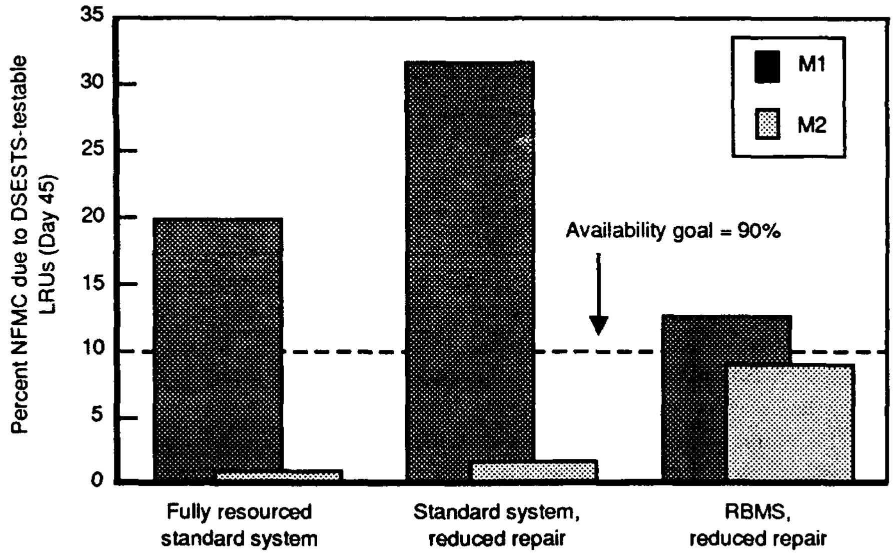


Fig. 4.4—Effect of O&S Strategy 2—14 percent cost savings through reduced repair—on M1/M2 availability

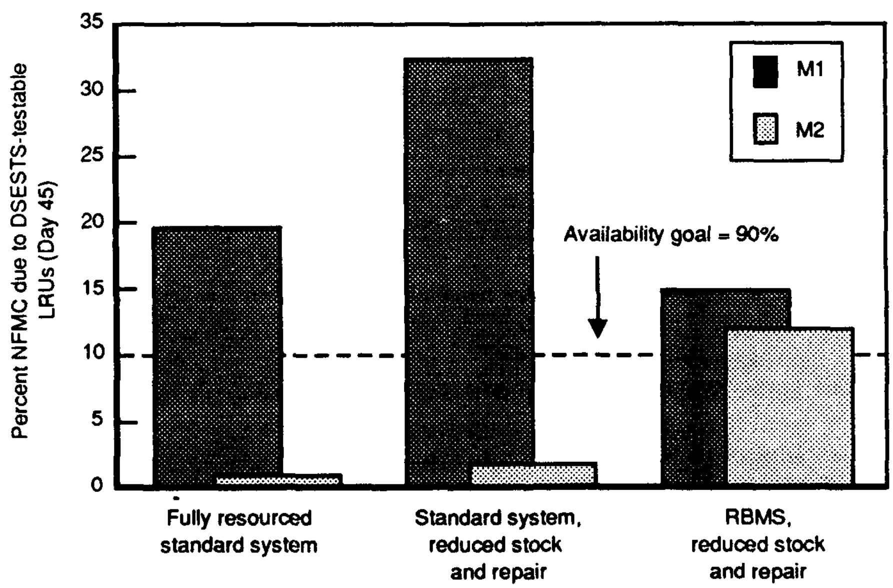


Fig. 4.5—Effect of O&S Strategy 3—34 percent cost savings through reduced stock and repair—on M1/M2 availability

weapon systems to meet the stated 90 percent availability goal because it still gives unnecessary priority to M2 parts (even reduced by half, they are still in excess). A system with RBMS, however, allows both weapon systems to meet stated goals.

Figure 4.4 shows the effect of following Strategy 2 and reducing TMDE by 25 percent. Since this case deals with a resource not in excess, further cuts portend loss of effectiveness unless the management system is improved. Compared to the fully resourced standard system, this strategy reduces M1 availability an additional 10 percent (to over 30 percent NFMC on day 45). Applying RBMS, however, makes even these 14 percent cost savings acceptable; M1 availability is increased relative to the fully resourced case; and M2 availability, while less than in the standard system, stays within the goal.

The same conclusion emerges when we follow Strategy 3 and combine stock and TMDE reductions to save 34 percent in total costs (Fig. 4.5). Given that M2 stock was in excess, there is only minimal performance degradation when we reduce stock in addition to TMDE. As in the last example, the value of an effective management system like RBMS is apparent. It allows both weapon systems to be brought into balance, such that overall one is no worse off, but in fact better off, with RBMS and reduced resources than one is with full resources and no RBMS.

Summary of Division-Level Prototype Analysis

RBMS may be successfully employed at the division level and can play a critical role there in providing fighting units with the weapon system availability they need to accomplish their mission. In particular, this analysis has shown that RBMS can:

- Increase weapon system availability;
- Greatly increase availability of weapon systems suffering imbalances of resources;
- Help commanders meet each weapon system's availability goal through judicious balancing of support;
- Maintain high weapon system availability even with substantial cuts in resources.

ANALYSIS OF THE THEATER-LEVEL PROTOTYPE

The previous case demonstrated RBMS's capabilities at the division level, in which weapon systems with relatively cheap components competed for limited repair resources. This next case examines support for a single weapon, but one that is much more complex, has components that are an order of magnitude (and often two orders) greater in cost, and relies on repair resources—themselves expensive and dependent on significant expertise—that must be located farther from the using units and must be able to cover a wider range of components and customers.

With this prototype, we investigate one of the Army's most sophisticated weapon subsystems in its main maneuver units: the TADS/PNVS of the AH-64 Apache attack helicopter. The TADS/PNVS system has direct optics, advanced forward-looking infrared, and laser designation/tracking capability that allows it to be used round-the-clock in any environment or condition; it uses one of the Army's more lethal anti-armor weapon systems—the laser-guided HELLFIRE missile.

The TADS/PNVS is a costly subsystem, with its most sophisticated removable components costing over $150,000 each. Its complicated electronics and highly advanced electro-optical features increase its dependence on equally sophisticated intermediate repair, represented by the $10 million electronic equipment test facility (EETF), and on depot-level repair, currently handled by contractor-run SRAs, which are small, fast-turnaround, forward-located facilities that depend on sophisticated hot-mockup systems operated by highly skilled technicians.

The TADS/PNVS LRUs enter fault isolation at the EETF, which houses a piece of test equipment that repairs many items on many Apache subsystems (less than half of the EETF workload is for TADS/PNVS parts). Repairs that the EETF cannot handle are passed on to one of four SRAs run by Martin Marietta located near operating bases. Currently, there is only one TADS/PNVS SRA test set located in Europe; our analysis assumes that one more is made available to support the deployed force in combat. During wartime, the EETFs will operate at corps level and the SRAs may operate at theater level.

The prototype examines the 26 LRUs that comprise the TADS/PNVS system and covers three corps of Apaches based on current fielding. Like the previous case, it uses CAA's P90E scenario, modeling 198 Apaches in three corps. The analysis will help investigate some pertinent issues of SRA use:

- The use and payoff of new management concepts for depot-level repair in a type of facility created to expedite repair of expensive and critical components.
- The utility of new management systems in a "consolidated" repair facility located in EAC intended to lower support costs with no loss in productivity.
- The ability of remotely located repair (such as an EAC location) to respond to critical unit needs even with uncertainties and inaccuracies in data.

Benefits of RBMS in the Current Support Structure

Employing RBMS in the TADS/PNVS support structure as currently operated proves beneficial, as Fig. 4.6 demonstrates. Similar to the first case, the figure shows the percentage of NFMC TADS/PNVS systems over a 60-day scenario, comparing a standard system with FCFS policies (with no prioritizing management system) and one using RBMS. The results indicate that using RBMS yields only moderate improvement. Until day 30, there is virtually no effect from RBMS, and only after day 45 does the benefit become fairly sub-

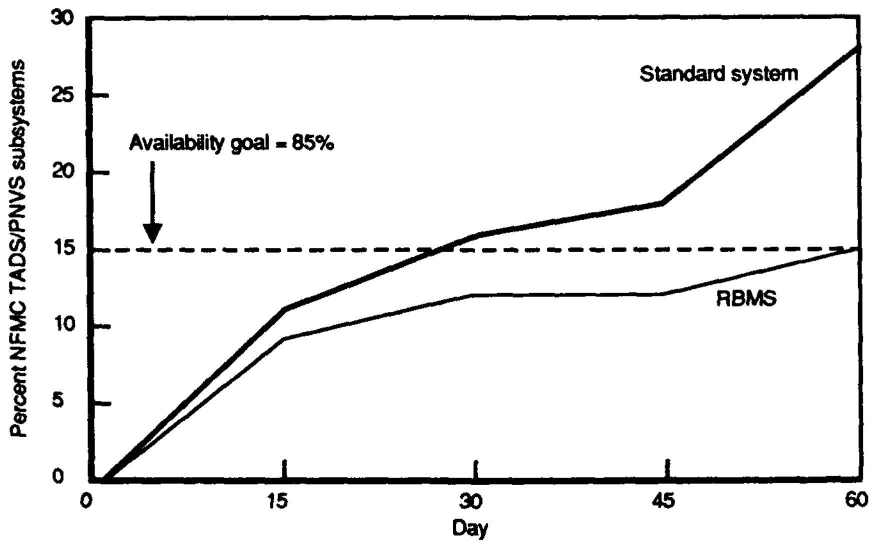


Fig. 4.6—Effect of RBMS on TADS/PNVS availability

stantial. What accounts for this difference from the previous case? The main reasons are lack of scope and a dispersed support structure. While the SRA in this structure is located in EAC, the intermediate-level EETFs are based within corps. The EETFs are isolated from each other and, thus, cannot share available test equipment nor serviceable LRUs they make available. Although RBMS might be operated at the EETFs, the dispersed nature of the structure and the lack of scope tend to inhibit the payoffs.

In the same way, the payoffs from RBMS at the SRA are relatively less because of the smaller leverage given to the theaterwide repair facility. Since a substantial amount of TADS/PNVS repair is handled at the EETF, the SRA is less able to exploit RBMS in meeting overall availability goals. In fact, as modeled, RBMS is seeing less than 50 percent of the entire EETF workload (versus 100 percent of the DSESTS workload modeled in the division-level prototype). Thus, whatever benefits RBMS provides, it provides them based on only half the number of actions to which it could apply.

Role of RBMS in the Face of Resource Constraints

The nature of the SRA allows us to examine a unique strategy for reducing O&S resources without degrading capability of the TADS/PNVS: consolidating the TADS/PNVS repair at an EAC facility we can call "a consolidated SRA." A consolidated SRA would consist of both SRA and EETF facilities, with management systems determining their division of work.[7] This consolidation would allow a reduction of TMDE and personnel and would likely result in more effective EETF performance, better utilization of SRAs, and greater scope of repair across an entire theater.

Figure 4.7 shows the cost savings of such a consolidated SRA. The baseline costs include the cost of spares and the operation of EETFs and SRAs to support the TADS/PNVS subsystem in three corps.[8] As

[7]Other RAND work is currently exploring such a concept. For a general discussion of SRA operations, see M. L. Robbins, M. B. Berman, D. W. McIver, W. E. Mooz, and J. F. Schank, *Developing Robust Support Structures for High-Technology Subsystems: The AH-64 Apache Helicopter*, The RAND Corporation, R-3768-A, forthcoming.

[8]Spares costs are from existing stocks, not requirements, prorated to support the 198 systems modeled here. EETF costs were obtained from the Aviation Logistics School, Fort Eustis; SRA costs were obtained from the Program Manager's Office, TADS/PNVS. Unlike in the DSESTS case, there was no obvious overbuy of these expensive LRUs; thus, we do not consider a stock reduction strategy.

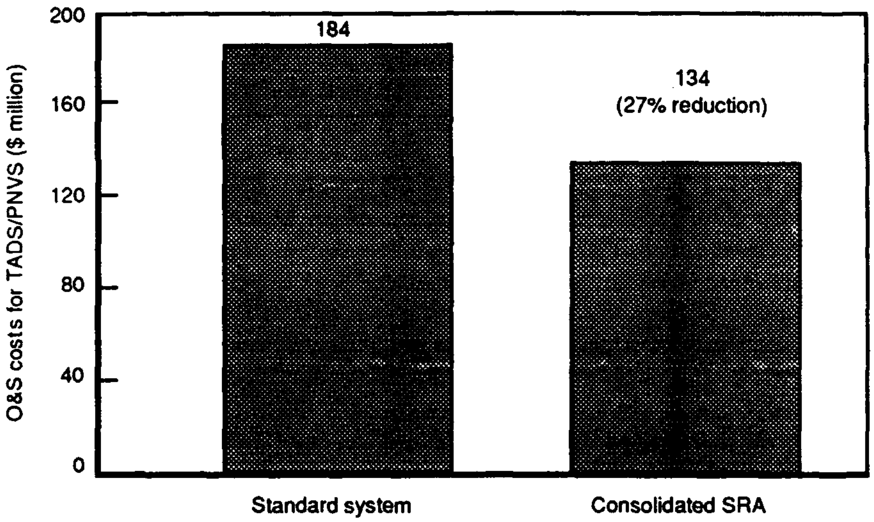


Fig. 4.7—Cost savings of a consolidated SRA structure for TADS/PNVS subsystems

shown, a consolidated SRA might yield costs savings of more than 25 percent in supporting the TADS/PNVS.[9] Of special interest here is that such consolidation would allow RBMS to be applied to 100 percent of TADS/PNVS repair serving all weapons in the area of operations.

Figure 4.8 compares the performance of the consolidated SRA with different management concepts, carrying forward from Fig. 4.6 TADS/PNVS availability in the base case (i.e., fully resourced with no prioritizing management system). Clearly, trying to save money by reducing the number of test stands through consolidation is not an effective strategy without a change in management system. Specifically, past day 30, using a standard system with fewer test stands significantly decreases weapon system effectiveness; by day 60, almost half of the Apaches are unavailable because of TADS/PNVS.

[9]This is a lower-bound estimate in that it considered all EETFs as already bought and so sunk costs; only O&S costs, personnel, and modification costs for the EETFs are considered. In the case evaluated here, the number of EETFs for the three corps was reduced from three to one. At a purchase cost of $10 million each, this could potentially increase the overall cost savings by a further $20 million.

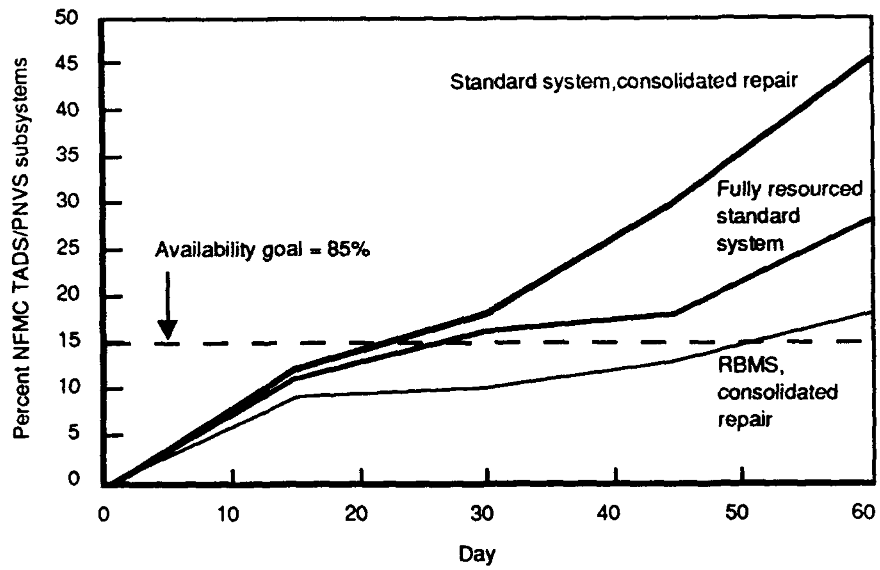


Fig. 4.8—Effect of consolidating repair on TADS/PNVS availability

Not surprisingly, a system using RBMS does much better. The number of NFMC systems is halved on day 30 and reduced by two-thirds on day 60. Indeed, even with fewer test stands, RBMS performs better than the fully resourced standard system.

Adaptivity of RBMS to Wartime Uncertainties

The foregoing analysis assumed RBMS would not be plagued by information problems—that the system would be able to predict future operations accurately.[10] Such an assumption would not, of course, meet the test of reality, since war would follow no set script, and no logistician could accurately predict future demands on combat units over a two-week window.

The inability to forecast perfectly will degrade the ability of any management system to make good decisions. But no management system should (or could) be based on an assumption of perfect foreknowledge. Given the "certainty" of wartime's manifold uncertainties, the relevant questions are: How much degradation in perfor-

[10]The information, however, was not assumed to be perfect, or real-time. Data on asset status (resources available, deadlined weapon systems, etc.) were updated at most every 15 days in the analysis.

mance is likely, and how can we adapt the management system to minimize that degradation?

The next phase of our analysis uses the TADS/PNVS SRA prototype to demonstrate the problems and potentials of dealing with bad information. Figure 4.9 shows the results of this analysis. The first set of bars on the graph shows weapon system availability when perfect knowledge of the future is assumed among a sample of units included in the model; also assumed is that all units have the same goal (here set as no more than 15 percent of aircraft deadlined for TADS/PNVS). In this particular scenario, the 3/1st Combat Aviation Brigade was expected to carry the load, while the 6th Cavalry (in both III and VII Corps) was virtually disengaged.

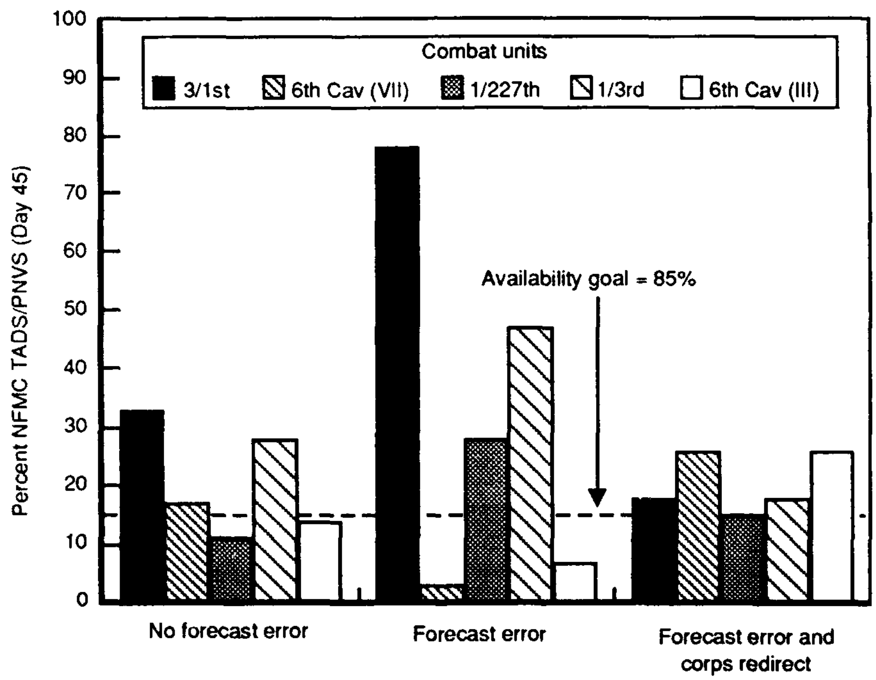


Fig. 4.9—Ability to meet unit goals for TADS/PNVS subsystems, with error and corps redirect

The second set of bars for these same units reveals the cost of inaccurate information. We generated these results by misleading the DRIVE model about future operations. An error function was randomly introduced into the projected operating tempos for each unit—telling DRIVE that the units would operate either 50 percent greater or 50 percent lower than in fact they would in the "real world."[11] As a result, DRIVE is led to make decisions that are somewhat disconnected from the real world. Thus, units that are disengaged receive spare parts to fill holes in aircraft that never materialize, and units that are heavily involved in combat are starved for resources that never appear.

As the bars reveal, such an uncorrected system could be disastrous. For example, because of incorrect data provided to RBMS, the 3/1st Combat Aviation Brigade quickly falls to less than 25 percent available helicopters. Spares that would have supported that unit go instead to the 6th Cavalry (both the III and VII Corps), even though they are virtually disengaged.

An RBMS system that operated like this would, of course, be of little use to the logistician or the commander he supports. We believe, however, that a more sophisticated, multi-echelon application of RBMS would remedy these types of problems. The results shown in the last set of bars reveal the potential benefit of operating the distribution portion of RBMS at an intermediate echelon, in this case at the corps level. Being closer to the operations themselves, this system would be able to update information more frequently and redirect assets coming from the consolidated EETF/SRA facility based on current information. Instead of operating with a 15-day window of information back at the SRA, the corps might be able to update future needs of the combat units daily.[12] If so, it could correct mistakes in units' anticipated fighting tempos that led to the misdistribution of resources shown in the middle part of the figure.

The last set of bars shows the dramatic improvement achieved by correcting those mistakes daily. Each unit can now come close to its set goal of no more than 15 percent of aircraft NFMC because of the TADS/PNVS.

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[11]The real world here is Dyna-METRIC, which evaluated the DRIVE decisions against activity levels with no forecast errors.

[12]Of course, if the SRA were close enough to operation, in the same theater, perhaps daily updates of information would be good enough to eliminate the RBMS redistribution system upfront.

Summary of Theater-Level SRA Prototype Analysis

Using a multi-echelon structure for RBMS offers the potential to deliver high combat performance and meet commanders' goals even when faced with the uncertainties of wartime. It also offers the potential for maintaining support system capability with reduced resources.

ANALYSIS OF THE DEPOT-LEVEL PROTOTYPE

In the previous cases, RBMS achieves effectiveness in supporting combat through its high leverage on LRU repair. In many cases, however, and especially at the depot level, LRU repair does not play as great a role. Instead, the depot facility is more important in terms of SRU repair, management of wholesale war reserves (both LRU and SRU), and supporting theater-level LRU repair by furnishing the SRUs that make forward-level repair possible.

The third prototype helps us examine a case at the depot level in which leverage on weapon system availability through LRU repair is small, yet the depot can potentially play a major role in supporting combat operations by judiciously managing wholesale war reserves. The case chosen for this analysis is the electro-optical shop at SAAD,[13] which fixes mostly night vision components of a wide range of weapon systems, including M1s and M2/3s.[14] It has four types of TMDE for isolating faults on six LRUs and 30 of their SRUs: TSTS and Bradley optical bench for LRUs, and EQUATE and ADADS for SRUs. The prototype examines the benefits of RBMS compared with a standard system for LRU and SRU repair and distribution servicing nearly 14,000 weapons in three corps in the same P90E scenario.

In the prototype, intermediate levels of repair are explicitly modeled to reflect the fact that most LRU repair is handled at division level. LRUs repaired at the depot itself are generated by the division MSB or brigade FSB determining it cannot repair them, or because of queue overflows.[15] As a result, the depot repairs only about 20

[13]An equivalent exists in the European theater at the Mainz Army Depot.

[14]The force composition for this prototype encompasses six armored divisions, eight mechanized infantry divisions, three armored cavalry regiments, four independent brigades, and four other divisions in five corps. These electro-optical items are used in the operation of almost 14,000 weapon systems, including over 3000 M1s and 2000 M2/3s.

[15]The standard for an overflow decision used here was a 96-hour backlog, per current Army doctrine.

percent of the LRUs supporting weapon systems. One consequence of this is that RBMS cannot have the same direct effect on weapon system availability as it did in the other prototypes.

Besides helping us examine how well RBMS can help a CONUS-based location support wartime operations in a distant theater, this prototype allows us to explore two questions regarding the "lower bound" of RBMS usefulness and the heart of new management concepts:

- How much can this management innovation help when its leverage over the entire scope of weapon support is relatively small?
- How can we best use the scarce resources we have not only to increase overall system effectiveness but to concentrate its support at exactly the right time and the right place?

RBMS Impact on Overall Availability

Figure 4.10 compares availability of the M1 tank, as a function of the LRUs modeled, over the 60-day scenario for both the standard system and one employing RBMS at the depot.[16] RBMS provides a benefit in terms of overall weapon system availability: the M1s NFMC decrease some 3 to 5 percent in a system with RBMS. That said, however, 3 to 5 percent is not a large improvement. As argued above, this occurs because repairs guided by RBMS are limited by the scope of repairs performed in the depot.

Limited repair scope means limited leverage for increasing overall weapon system availability; specifically, if "good" or "bad" decisions are being applied to only 20 percent of the entire repair workload, no great payoffs in number of weapon systems available should be expected when "good" decisions are made using RBMS.[17] This, however, does not exhaust the advantages of using an RBMS-based management system.

[16]We show the effect on M1s only. Results for the M2 are similar and, as there is little of the shared test stand contention issue as in the DSESTS case, showing M2 results would reveal nothing more. In every case analyzed in this demonstration, availability of common night vision systems supplied by existing stockpiles remained extremely high (above 95 percent).

[17]Although the depot performs 100 percent of SRU repairs, there is such a large supply of SRUs that prioritizing their repair—indeed, even repairing them—did not make a difference across the 60-day scenario. Reducing SRU stocks may yield dollar savings, but the savings are not likely to be great (given the small unit costs).

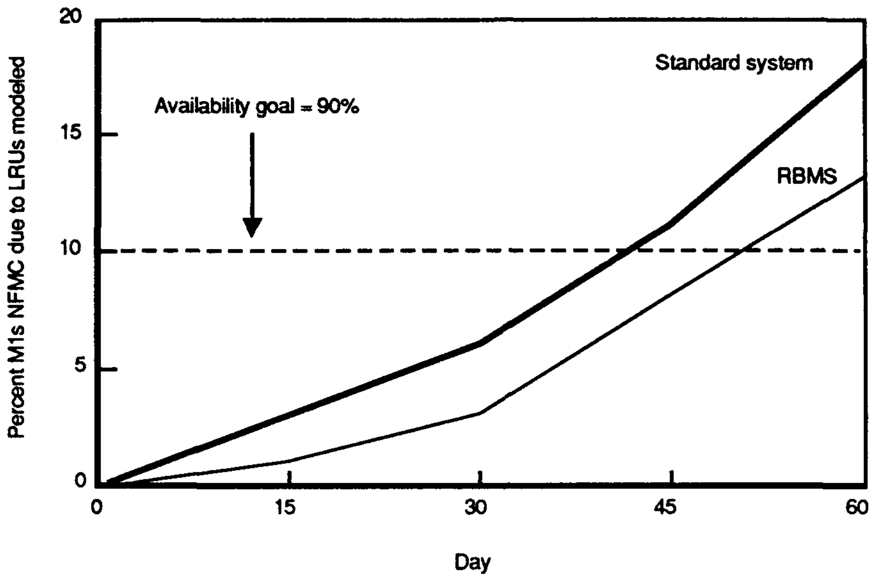

Fig. 4.10—Effect of RBMS on M1 availability for SAAD-reparable components

Ability of a Push System to Meet Unit Goals

RBMS also helps distribution decisions about allocating serviceable components (both LRUs and SRUs) from repair and from wholesale war reserve stocks. Applying the RBMS logic gives the IM a new tool to meet wartime needs: to anticipate future demands of the units in greatest need. By employing a push strategy whereby serviceable assets are identified for delivery to units even before requisitions are received or before holes in weapon systems or LRUs eventuate, RBMS can help guarantee, if not higher total availability, certainly higher "critical" availability (i.e., higher weapon system availability for the units most actively engaged in combat).[18]

[18]This does not imply that the requisitioning system needs to be abandoned. In the case where assets are scarce, RBMS can help decisionmakers decide which requisitions should be filled first to maximize weapon system availability goals. If there are no requisitions for a distribution action RBMS suggests, a notice could be sent to the

This calls for a prioritizing system unlike the current Army standard, which does not differentiate among units already in the combat theater; units will differ in intensity of operations, whether they lie along the axis of the main enemy thrust, whether the unit will play a key role in a planned counterattack, etc. As planned, VISION would allow the commander to communicate these different types of priorities to the logistician all the way up to the depot programmer and IM in CONUS.

Figure 4.11 demonstrates RBMS's ability to meet this need, showing the results of a push system for wholesale-level LRUs and SRUs. For the three corps modeled, it shows the commander-set availability goals. In this scenario, the main thrust will be made in III Corps—hence the need for the availability goal of around 93 percent. A secondary thrust is made against VII Corps, and the units in V Corps are faced with no more than an enemy screen—hence, the need for less stringent availability goals.[19]

The light bars show how well the standard system meets the goal. As shown, the system tends to reverse priorities so that the least im-

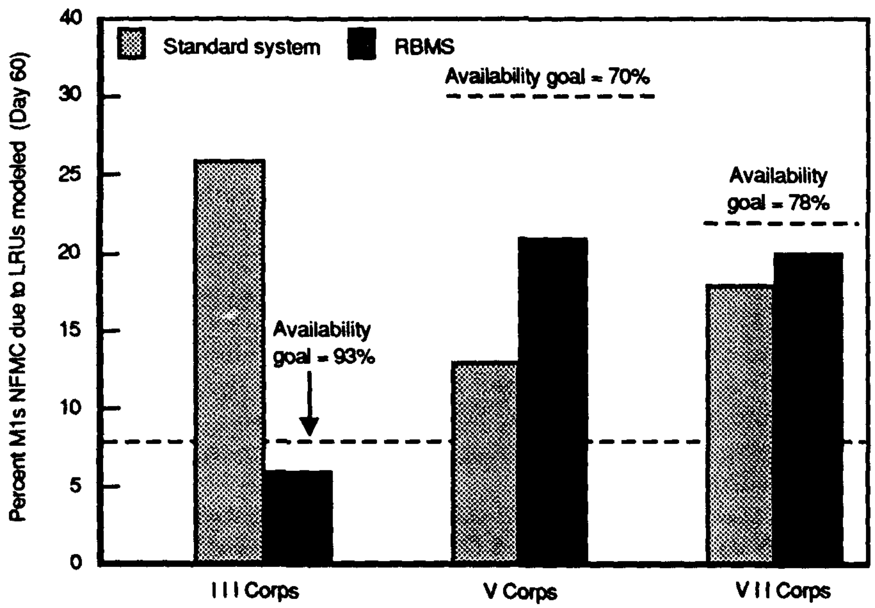

Fig. 4.11—Ability of RBMS vs. standard system to meet varying unit availability goals

receiving unit indicating that the asset is being forwarded to it. The receiving unit could cancel the shipment if it deems it is not needed.

[19]The corps-level availability goal shown on the figure is approximate as it represents an average of availability goals of all divisions in the corps.

portant units achieve the highest availabilities, whereas the most critical corps, the III, ends up with more than 25 percent of its tanks unavailable. (This reversal occurs because units that are least stressed—and so suffer fewer failures needing replacement—are the easiest to keep at relatively high availability levels.)

The dark bars show how an RBMS push system can help in anticipating future unit needs. The contrast to the standard requisition-based pull system is striking. The III Corps, which faces the main enemy attack, meets its availability goal and better; the unengaged V Corps by contrast is relatively starved (although it too does better than the goal originally set); and the goal of the partially engaged VII Corps is also bettered (although not as much as it was with the standard system). Figure 4.9 had revealed that RBMS does better in delivering the total number of weapon systems that are combat capable. However, more importantly, RBMS delivers these systems more nearly where they are needed. Specifically, although RBMS produces no more than 5 percent more tanks overall, it reduces the number of NFMC tanks in the critical III Corps sector fivefold.

A Multi-Echelon RBMS to Adapt to Wartime Uncertainties

As impressive as these advantages are, a push strategy works only if the logistician knows the right location to which to send stock. Thus, such a system would depend heavily on its ability to obtain current, accurate information or compensate for its age or inaccuracies. Since inaccuracies in data will inevitably occur, especially in wartime, the system must be built to identify and correct its mistaken views of the world.

Figure 4.12 shows the results of an analysis similar to that done for the theater-level prototype. It communicates the deficiencies of a push system operating with incorrect information, as well as the advantages of a push system modified by the operation of a corps-based "redirection" function.

Once again, the units with the highest anticipated operating tempos, such as the 2nd Armored Cavalry Regiment (ACR), are likely to suffer the greatest number of NFMC tanks, whereas the least-pressed units (principally, 1st Mech and 5th Mech) are likely to be those in the best shape. The addition of RBMS at a corps MMC to redirect assets eliminates much of this imbalance, because the system has more

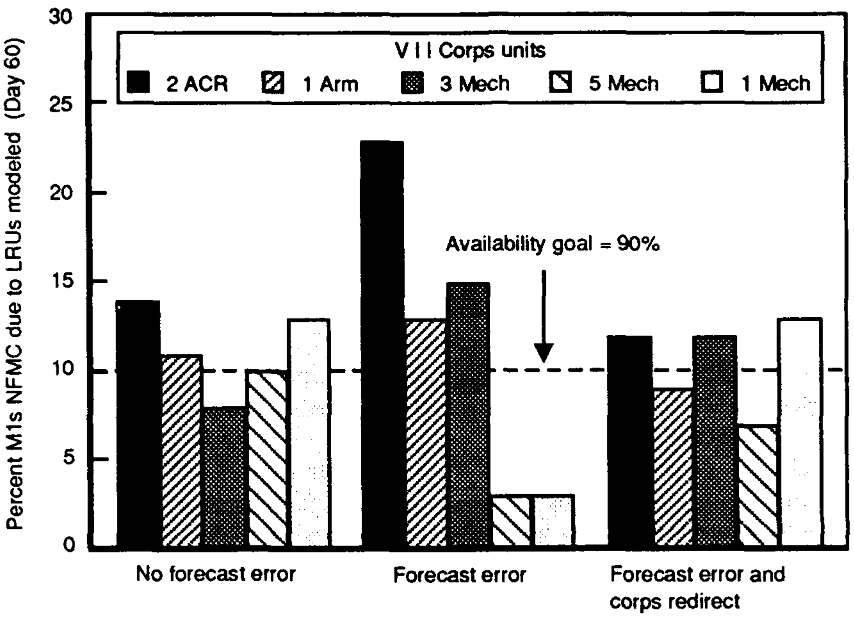

Fig. 4.12—Ability to meet unit goals, with error and corps redirect (VII Corps)

current operating tempo information than was available when the IM made distribution decisions. By preventing excess spares from going to the mech units, it lowers the availability of those units; however, it increases the ability of critical units, like the 2nd ACR, to fight.

This example raises questions about the location and, therefore, the usefulness of a redirection capability. Here it is placed in the corps MMC and it functions to correct imbalances among the corps units. In Fig. 4.11, however, the great disparities in weapon system availability occurred between corps. As a result, a corps redirection capability cannot help the III Corps increase its combat power if the needed spares are going instead to the V Corps.

Yet, placing such a redirection facility behind the corps, such as at the theater MMC, is also problematic. It creates another structure layer, with its own necessary delays built in,[20] and may not be able to obtain as accurate and timely information as a corps facility could. In addition, a multiple-theater conflict could exist in which the

[20]The corps redirection facility was assumed to add one extra day to the OST.

"redirection" facility would be located with the IM. These and similar issues must be resolved in creating a new management structure that includes RBMS.

Capabilities of a More Sophisticated RBMS

Such a structure should also deal with an RBMS-based management system not yet considered, one with capabilities beyond the bounds of RBMS as presently developed but by no means impossible to achieve. In addition to the kind of redirection function discussed above, a future RBMS could pursue redistribution functions in which stocks of spare LRUs and SRUs currently located at a unit could be allocated to support another unit in the same corps or a different corps.

This kind of system would be a fairly radical step. Not only would it tolerate holes in weapon systems at a particular location, it might also take away spare parts that would fill those holes, perhaps even delivering them to a unit with no due-outs (though one that would be expected to greatly increase its draw on spares after going into combat). Such capabilities already exist in the Army in rudimentary form.[21]

The system could be extended to deal with unserviceable assets as well as serviceables. As such, it could move excess reparables from a possibly overextended queue at one location to another source of repair at a less overloaded repair facility. The goal of redistributing both serviceables and unserviceables is to squeeze maximum performance out of all available resources in meeting combat goals in the time and place most needed. Thus, RBMS becomes a major step toward achieving the goal of a "seamless" logistic structure.

Implementing such a system portends major changes in the Army's way of performing Class IX support. In particular, it calls for ending traditional divisions between wholesale and retail echelons and resources, as well as for changing the idea of "stock funded" items and other ways of accounting for "ownership" of resources. It would place less emphasis on unit-controlled stock, such as ASLs, which might be smaller or even eliminated altogether.

The complete visibility anticipated would allow the development of a truly seamless system, but it also raises the question of who would

[21]This type of redistribution was pursued in the OSC field test at Fort Hood; a similar kind of system is in use in the V Corps under the name CAV—Corps Asset Visibility.

control the system and how responsibility would be partitioned. The role of IMs at the MSCs would be changed—their role would expand or shrink. The same holds true for the role of the theater MMCs, which might end up with a much larger set of resources to exploit and increased responsibilities for apportioning resources among the various units. There are also questions about who should manage multiple theater operations and what the control procedure should be for depot-level repair done in theater (such as at SRAs).

CONCLUSIONS

These questions scratch the surface of the challenges the Army faces in developing a more responsive management system. As shown in the analysis presented here, developing such a system, of which RBMS is a part, is worthwhile because the system offers valuable payoffs—not only increases in weapon system availability, nor even just increased availability at lower cost, but, most importantly, an increased probability that resources will be made available to the units that need them most, when they need them most. Still, this system will undoubtedly create a challenge for the Army. Pursuing this new system is not just a matter of adapting computer algorithms or of building new data systems. It involves adapting an entire management system—including command and control, ownership and direction of resources, and coordination and integration among echelons and functions—to the new possibilities inherent in the system.

Yet there may be no alternative. As resources decrease, the Army will have to do more with less. A smaller Army will rely even more on the combat multiplier effect of high technology, despite its ever-increasing price tag. Information, and the exploitation of that information, is the "cheap" alternative to paying more money for increasingly expensive resources or to reducing goals themselves because those resources are so scarce and costly.

V. USER PERSPECTIVES ON OPERATIONAL PROTOTYPE IMPLEMENTATION

Evaluation of the three demonstration prototypes has shown that RBMS can improve weapon system availability. The logical next step is to develop an operational prototype in a live work setting to help set repair and distribution priorities for a limited set of critical spare parts.

However, as research on implementing information systems confirms, it is essential to first address any obstacles to success, conflicts the system introduces for users, and design considerations that will make the system most useful. Addressing such concerns is all the more important for RBMS because it is not just automating manual operations and tasks—it is introducing to users a new set of work objectives that is based on unit-level weapon system availability goals.

This section focuses on the third purpose of the demonstration prototypes—assessing the usability of the system. Obtaining feedback on RBMS from its future users provides guidance to those planning the design and implementation of an operational prototype. Following brief discussions of the goals of gaining user perspectives and of the methodology employed to obtain them, we examine problems identified by users and recommend possible solutions.

GOALS OF OBTAINING USER FEEDBACK

The following goals guided our review of user perspectives on RBMS:

- To understand how those individuals with the types of jobs affected by RBMS now prioritize the repair and distribution of critical spare parts and what rules, policies, and procedures they follow.
- To identify potential conflicts for RBMS users caused by such rules, policies, and procedures and determine how these could be changed or waived to eliminate such conflicts.
- To identify how the users' performance is measured formally and informally up the chain of command and how using RBMS may affect this performance measurement.

- To identify any features of the operational prototype design that would make RBMS a more useful decisionmaking support tool for its users.

METHODOLOGY TO DETERMINE USER PERSPECTIVES

To conduct the review, we interviewed two types of users with positions RBMS will directly affect: IMs who manage and decide how to distribute secondary items; and those who plan, monitor, or schedule repair of spare parts. We also interviewed two levels of supervisors for these users in separate groups and a few people responsible for monitoring policies and developing procedures affecting spare parts distribution and repair.

We conducted these interviews in August 1989 in several sessions at three sites: (1) AMCCOM (those involved with M1 tank and M2 Bradley secondary items); (2) AVSCOM (those involved with both Black Hawk and Apache secondary items); (3) and SAAD (those in the electro-optical shop who conduct repairs of secondary items managed by AMCCOM, MICOM, and CECOM and used on several weapon systems). In total, we interviewed 42 people. Because we interviewed only a small sample of potential RBMS users, we were not able to include potential users involved with the full range of weapon systems, reparable items, and MSCs. Since other issues particular to such areas may arise when an operational prototype is implemented, we suggest that the managers of the chosen prototype site review this section to identify additional conflicts or improvements needed.

In interviewing each group, we followed the same structure. We began by providing an overview of the RBMS concept and how it might be implemented in a work setting. As part of this presentation, we used the RAND PC-based demonstration to discuss how the DRIVE model constructs priority lists.[1] We then asked six questions, elaborating as needed to understand interviewees' responses.

- How do you now prioritize repairs and distributions?
- What are your objectives when you do so?
- What hinders you from meeting these objectives?
- How do you know when you are doing your job well (i.e., how is your performance evaluated)? How might RBMS affect this?
- If you used RBMS, what procedures, policies, or regulations might present conflicts?

- Are there ways RBMS could be changed to improve its usefulness as a decision support tool for users?

POTENTIAL PROBLEMS FOR RBMS USERS

Based on our interviews, we identified nine conflicts or obstacles that could hinder users in successfully implementing an operational prototype of RBMS.

1. RBMS transaction-based push versus pure requisitioning
2. Potential mistrust of RBMS data sources
3. Customer service versus worldwide weapon system availability
4. Item managers' discretion versus RBMS algorithm
5. Programs emphasizing management of certain items
6. Performance measures versus following RBMS priorities
7. Contract repair constraints
8. Annual repair programs versus RBMS short-term priority lists
9. Availability of bits and pieces and unserviceables for repairs

Each problem is discussed below; suggested solutions are discussed later in this section.

1. RBMS Transaction-Based Push Versus Pure Requisitioning

IMs and retail users of spare parts are governed by AR 725-50, which requires that supplies be requisitioned and issued in accordance with the Uniform Material Movement Issue Priority System (UMMIPS). Specifically, Section 1-6h states that "supply activities will make supply decisions based on the [UMMIPS-defined] priority designators." Section 2-6 refers to UMMIPS as "a way to express the relative rank of requisitions. . . ." It further defines the time standards IMs must meet in processing requisitions. Based on this regulation, the current requisition system automatically generates a notice of expected availability to a requisitioner if a requisition is backordered (not filled immediately).

The distribution of certain Army weapon system reparable assets is governed as well by a direct exchange procedure, requiring a unit to return an unserviceable asset for repair before honoring a requisition for a serviceable asset.

Finally, field units have ASLs for various items, including reparables. Requisitions are often generated automatically against these levels and, conversely, if a requisition would push a unit over its authorization, the requisition may not be honored.

Although RBMS distribution priorities may be similar to those resulting from following the regulatory requisition and priority process, ASLs, and even the direct exchange procedures, their results may diverge significantly because the approaches consider different data.

2. Potential Mistrust of RBMS Data Sources

RBMS calls for asset visibility of items at both the wholesale and retail levels. Although the source of asset data for the operational prototype has not been determined, IMs currently have access to retail asset data for a subset of items coded for SIMS–X reporting. Interviewees unanimously distrust the SIMS–X data and find the data unreliable and, therefore, unusable.[1] This raises a serious concern that lack of faith in data sources may undermine user trust in the RBMS product. Either users will ignore RBMS priorities (resulting in a flawed operational test), or they will follow the priorities and their morale and confidence in the Army systems to support them will suffer.

Success of the RBMS operational prototype faces two other potential obstacles related to mistrust of data sources. On the one hand, the prototype has to have bounds on the amount of complexity it incorporates. On the other hand, if users perceive the prototype reflects too simple a view of the world, they will mistrust its recommendations. In particular, interviewees stress the importance of the operational prototype having the capability to reflect multiple weapon system configurations and non-Army demands. They emphasize that weapon systems having many configurations affect how they distribute the secondary items they manage. For example, there are over 250 configurations for the TADS/PNVS alone. Interviewees report that they support a significant portion of non-Army demands—20 to 30 percent of repair work—for such clients as the border patrol, the Navy, and foreign military sales. These demands across sources are prioritized using UMMIPS definitions.

[1] Steps are being taken to improve SIMS–X reporting in the near term. Eventually, RBMS will rely on other more accurate sources of asset visibility, making this issue only a short-term concern. See Sec. III for a further discussion of data sources.

3. Customer Service Versus Worldwide Weapon System Availability

The current IM process separates ownership of assets between the wholesale and retail levels. Retail users in combat units "own" their assets and are responsible for their mission capability. IMs, in turn, view these retail users as their "customers." Their work objective is to satisfy customer demands (requisitions) as quickly as possible. According to interviewees, the personal relationships of mutual trust developed between IMs and their customers are important, because requisitioners need to accept an IM's decisions when tradeoffs have to be made. If this trust is disrupted, requisitioners can complain up the chain of command, making the IM's job more difficult.

This "customer" orientation will be disrupted by RBMS, which maximizes weapon system availability *across* combat units. Currently, IMs do make some tradeoffs between units' demands, but by using certain criteria not incorporated into the RBMS algorithm (e.g., long-term working relationships between the IM and the requisitioner, or even the IM's individual assessment of the relative importance of units' missions).

4. Item Managers' Discretion Versus RBMS Algorithm

IMs distribute scarce assets based on UMMIPS priorities, but they also consider other factors: (1) precedence afforded NMCS requisitions; (2) calls received from requisitioners about special situations or potential NMCS needs; and (3) their knowledge about individual users' asset levels (learned through site visits, phone calls, or other sources). In addition, they sometimes make judgments based on their assessment of the criticality of the missions of competing users. Further, they sometimes choose not to distribute scarce items immediately to have some available for unanticipated, high-priority demands. Hence, IMs use discretion in making distribution decisions, weighing several factors and drawing on their experience and skills. They are justifiably proud of their skill level, experience, and ability to balance user demands.

RBMS could easily appear to directly conflict with the use of these skills, because the system prescribes a priority list that already incorporates several of the factors IMs consider. This problem is further complicated by the fact that the IM needs these same skills to know when to override an RBMS priority. As stated earlier, RBMS priority lists should guide actions, not dictate them.

5. Programs Emphasizing Management of Certain Items

The Army and its MSCs have programs to ensure that certain items are managed especially carefully. Items in such programs are defined in various ways (e.g., by number of backorders or by unit cost). One such Armywide program, Aviation Intensive Management Item (AIMI), is defined in AR 710-1, 3-23 and referenced in AR 725-50, 4-19. IMs are not supposed to exceed negotiated AIMI stock levels as they release items against requisitions. Twice each year, the IM for an AIMI item chairs a conference with the MSCs to set the item's stock levels. Requisitions for such items are manually processed by IMs to reflect negotiated stock levels. Similarly, certain items may be labeled "specially managed items." These receive special attention from IMs and are monitored closely by maintenance.

Interviewees identified three other programs, emphasizing certain items. For instance, AVSCOM has an S-4 process to prioritize items for closer attention based on backorder levels. The highest priority items are those that have the most NMCS backorders, followed by backorders stopping overhaul programs and the like. AVSCOM interviewees also mentioned monthly "show stopper" lists from Fort Campbell and Fort Rucker with items needing attention. AMCCOM interviewees referred to a "High 200 Backorder List," which shows those items with the most backorders.

Although none of these programs dictates how an IM distributes items, each calls for an IM's attention based on criteria that could conflict with RBMS priorities. For example, if an item had high backorders but was not critical for weapon system availability at a certain point in time, RBMS would not recommend repair hours for it and the backorder list might lengthen.

6. Performance Measures Versus Following RBMS Priorities

An IM's performance is measured against his written performance standards. Because of the complexity of IM jobs, the standards require IM supervisors to subjectively judge IM performance and the supervisors can adjust the standards to reflect changed work objectives under the RBMS operational prototype.

However, the performance measures applied to IM teams (by weapon system) and their supervisors (and sometimes individual IMs if they alone manage a weapon system) are more problematic for RBMS users. AVSCOM and AMCCOM use stock availability (i.e., the percentage of requisitions that can be filled immediately) as the measure.[2] This performance measure, which receives significant attention in the formal IM review process, conflicts with the RBMS approach.

A similar potential conflict exists in the repair function. According to interviewees, maintenance programmers (those at MSCs who negotiate repair levels annually for their IMs) have a work objective, at least informally, to meet IM annual repair requirements, revised quarterly or more frequently when needed. These requirements, discussed further below, may directly conflict with the shorter-term RBMS priorities.

Production controllers at the DESCOM repair depots (and repair teams of which they are members) are measured by three criteria: (1) how well they meet the repair programs in their annual plan, (2) how well they maximize repair hours per work center, and (3) how well they meet their more specific monthly plans (called "prognoses" in the electro-optical shop at SAAD), that is, their detailed repair plans that more closely reflect availability of repair equipment, unserviceables, bits and pieces, and workers. If the production controllers follow short-term RBMS priorities (e.g., biweekly lists), the work they perform, while contributing directly to combat effectiveness, may not use resources as efficiently as the current system because of small-batch repairing called for by RBMS priorities.[3]

We did not interview spare parts supply managers in combat units as part of this review. However, their performance measures are also probably tied to supply availability (e.g., the frequency that what is needed is on hand and the infrequency of NMCS items, or the achievement of planned stock levels). If these or similar measures are used, RBMS could penalize a field supply manager in a particular combat unit by recommending that a scarce item be distributed to another, worse-off unit, even though the supply manager had requisitioned the item on time to meet his stock level goals.

[2]An alternative measure mentioned by interviewees at AMCCOM, "adjusted stock availability," is similar: the percentage of requisitions that can be filled within 25 days of requisition acceptance by the IM.

[3]Smaller batches may be less efficient, because a repair test stand may have to be reconfigured for each new batch, thus lengthening the time needed for each unit of repair because this set-up time would be spread over fewer units in a batch. The interviewees for this review did not consider this a significant problem, given the types of test stands they use, but it may be a problem in other repair areas.

7. Contract Repair Constraints

According to interviewees, a typical Army repair contract for secondary items currently has only annual repair requirements (in an annual delivery order against a three year contract) by line item with little flexibility for the Army to modify requirements on a short-term basis. Further, the contract has a minimum and maximum level, the minimum being no higher than the number of unserviceables ready for repair at the beginning of the delivery order. The Army monitors progress against the annual delivery order monthly or quarterly but typically does not adjust the quantities to be repaired.

If the RBMS operational prototype is used to manage repairs by a contractor, RBMS would produce a short-term (biweekly) prioritized repair schedule for the contractor, reflecting the contract's fiscal constraints and the flexibility of the contractor's repair equipment and labor. This, in turn, means changing the terms of the contract.

8. Annual Repair Programs Versus RBMS Short-Term Priority Lists

Currently, IMs develop requirements studies for the items they manage, estimating annual (and longer-term) procurement and repair requirements. Those repair requirements are ultimately combined with the repair requirements of other items using common repair resources in annual repair programs negotiated between maintenance programmers, IMs, and DESCOM. The programs affecting a particular repair work center are combined in an annual plan.[4] Progress is monitored against the plan by program using quarterly in-process reviews (IPRs). Sometimes the plans are adjusted at the IPRs based on availability of unserviceables to fix and bits and pieces.

Repair work centers use these plans to develop monthly repair schedules. Thus, the repair function has a fairly firm annual plan it is measured against and more specific quarterly and monthly plans for workload scheduling. Under RBMS, however, a repair work center will be given shorter-term repair lists (e.g., biweekly). Although RBMS can be used to produce a longer-term priority list for planning purposes, the RBMS concept calls for a repair facility to follow the shorter-term lists that reflect dynamic changes in combat unit asset

[4]At the time of our interviews, annual repair requirements for the European theater were negotiated in a separate process at an annual scheduling conference. This process is in transition, however, with management control being moved back to the wholesale level.

positions, operating tempo, and the like. The cumulation of these shorter-term repair lists may or may not be close to the longer-term planning list. Further, an RBMS prioritized list may direct a repair work center to exceed the number of repairs for a particular item in the annual plan or even repair an item not listed in the plan.

9. Availability of Bits and Pieces and Unserviceables for Repairs

According to interviewees, repair work centers annually preposition bits and pieces they anticipate needing based on their approved annual repair plan. Given the lead times involved in acquiring needed bits and pieces, longer-term planning is critical to meeting repair requirements. Even with such planning, interviewees in the repair function estimate that 20 to 30 percent of their planned repairs are delayed because they lack needed bits and pieces. During the year, the work centers order more bits and pieces as needs are identified. The costs of these items are charged to a specific repair program.

Because RBMS calls for much shorter time horizons, methods to provide adequate stocks of bits and pieces need to be developed.

To help eliminate delays resulting from lack of bits and pieces, the Army has instituted a program to highlight critical maintenance repair parts (CMRP). Repair areas identify as CMRP any bits and pieces that will cause a repair program to halt within 30 days. Procurement then places priority on establishing contracts for such items and having them delivered expeditiously. Interviewees report that the program does indeed help solve a critical problem. RBMS should consider information that will help identify CMRP, so that the procurement system continues to be notified of items holding up the RBMS-managed repair areas.

Interviewees also report that the lack of unserviceables to repair sometimes constrains their ability to fulfill repair programs. If unserviceables are not available from the field, repairs cannot be made as planned, whether the current plan calls for repairs or RBMS does based on expected demand. Interviewees report that it sometimes takes up to a week to have available unserviceables delivered from depot storage sites. With annual plans and quarterly IPRs, such delays can be anticipated and built into the work schedule. Under RBMS's shorter-term schedule, such delays could present a more formidable obstacle.

RECOMMENDED SOLUTIONS TO IDENTIFIED PROBLEMS

Solutions to the above nine problems fall into four categories: (1) waivers to policies and procedures; (2) changes to procedures; (3) new procedures; and (4) user training. Whatever solutions are chosen, the rules for using RBMS during the operational prototype need to be made clear and explicit for the direct users and those in the field that are affected (i.e., those requisitioning the items to be managed by the prototype) through the users' chain of command. Also, if policies are changed or regulations are waived, changes also need to be reflected in the respective standard operating procedures developed at each MSC to translate policies and regulations into work procedures.

Waivers to Policies and Procedures

Waive UMMIPS Requisition Process. To eliminate any conflict between UMMIPS regulations and RBMS priorities, the UMMIPS process should be waived for test items for the test duration. IMs should use the RBMS priority lists rather than requisitions and backorder files to guide asset distribution. If the IMs know specific configuration data for the units, they should be permitted to routinely route assets to combat units that have no outstanding requisitions.[5] If combat units receive copies of release orders for such items and deem the release unnecessary or unacceptable (e.g., because it would hinder mobility), they can stop the release by sending an electronic message.

Similarly, direct exchange procedures for the return of unserviceable assets may need to be waived or at least revised. How these procedures are revised will depend on the test items involved.

To monitor how RBMS-prioritized distributions diverge from requisitions, the requisition process itself will not be "turned off" during the test for test items. Field units will continue to requisition test items (many of these requisitions are automatically generated for field units based on stock levels), but they will not expect to have them filled based on UMMIPS priorities or age of backorder.

This waiver appears to be the most important for an effective test of the operational prototype. It is especially important that those who requisition the test items are informed by their chain of command of

[5]In most cases, the combat unit RBMS recommends receive an item will have submitted a requisition. It is possible, however, because RBMS uses different criteria than individual users do, that RBMS will from time to time recommend an item to be released to a user with no outstanding requisition.

this temporary change in rules. During the prototype, any requisition for a test item should automatically generate a notice to the requisitioner to remind him that the item requisitioned is being managed under the RBMS operational prototype to maximize the probability of achieving worldwide weapon system availability goals.

Waive Authorized Stock Levels. Closely related to the above waiver, the authorized stock levels of test items must be waived during the test because distributions will be guided by RBMS, not ASLs.

Waive Process to Monitor Special Items or Add All Test Items. To deal with the problem of preexisting programs (like AIMI) that emphasize managing certain items, IMs for RBMS test items should be explicitly directed to ignore such programs; told explicitly which programs to ignore and which to use to override RBMS; or directed that all test items are designated for special monitoring.

Waive Most Existing Performance Measures for Test Participants. To deal with conflicts in performance measures for weapon system IM groups, maintenance programmers, production schedulers (and their repair teams), and field supply managers involved with RBMS test items, conflicting performance measures need to be waived (e.g., measures of supply availability from work standards and performance measures for IMs *and* their supervisors). Such waivers will help avoid the problem of punishing those who follow RBMS and end up with performance that seems poor. These performance measure waivers need to be reflected up the workers' chain of command.

Changes to Procedures

Change How Quarterly and Annual Repair Plans Are Used. Test participants will need to have clarified what annual (or quarterly) plan to use for long-term workload scheduling and prepositioning of parts. Eventually, if the RBMS concept proves successful, it can be applied to this longer time frame. For the operational prototype, we recommend that the annual repair plan be established using the current means. This annual plan can then be used for prepositioning parts and for any annual workload scheduling that needs to be done. On a quarterly basis, an RBMS list can be used to do shorter-term workload planning. Given the short-term, dynamic focus of RBMS, only the short-term RBMS repair list should be used for actual repair decisions and performance measurement. This means that the annual plan and repair programs need to be waived as instruments for conducting actual repairs, defining the universe of items eligible to repair, and measuring performance. Any annualized performance measurement should be made against the aggregation of the short-term RBMS lists, not against any longer-term RBMS planning list.

Increase Availability of Bits and Pieces for Repair. RBMS can be used more effectively to guide repairs if delays in repairs due to lack of needed bits and pieces can be reduced by increasing the quantity of bits and pieces work centers are permitted to stock, permitting these centers to preposition orders for bits and pieces on a quarterly (as well as annual) basis, reducing the procurement (where possible) lead times for such parts, and expediting their delivery to repair areas. These changes may increase depot inventory stock levels because more will be held temporarily in them. During the operational prototype, such potential inventory cost increases should be monitored and compared with the resulting increases in weapon system availability. We hypothesize that the cost of increases in the stocks of such bits and pieces will be outweighed by potential reductions in the number of reparables required to meet a given availability goal, because fewer costly reparables will be in the pipeline awaiting parts.

As noted, the repair function reduces work stoppages now by relying on the CMRP process to identify spare parts needing attention in the procurement process. If RBMS priorities are to be met, the RBMS operational prototype should somehow identify comparable bits and pieces needing expediting. Ideally, this list would show the implications of speeding up the availability of the critical bits and pieces in terms of achieving weapon system goals. Interviewees in the repair area are especially interested in having this kind of data available to share with those responsible for procuring the bits and pieces.

Enable Repair Contractors to Participate in the Test. Contract repair constraints do exist, but they are fortunately contractual vehicles that are amenable to applying the RBMS concept. For example, sometimes a repair contract is negotiated annually on a time and materials basis with a maximum funding level.[6] Such a contractual arrangement would probably permit an RBMS-managed work schedule with few changes. Still, the terms would have to be changed to enable the Army to provide short-term repair priorities for the contractor to follow and ways to monitor compliance with the pri-

[6]Interviewees at AVSCOM cited the Martin Marietta repair contract for repair of the TADS/PNVS as an example of such an arrangement.

orities and to identify acceptable reasons for noncompliance (e.g., lack of unserviceables or bits and pieces needed for the repairs). Such an arrangement may increase the unit repair costs because the contractor would have less flexibility to schedule the contracted repairs to maximize the efficiency of his operations.

Repair contractors using government furnished materiel are already required to report their repair activities and their use of such materiel to the Army frequently. This reporting process may be able to be adapted to include a way to systematically monitor repairs against RBMS priority lists.

Expedite Physical Distribution of Serviceable Assets to and from Combat Units. In addition to the problem of bit-and-piece availability already discussed, there is a problem of unserviceable asset availability. To help mitigate the problem of delays in this area, unserviceable delivery schedules should be reviewed for the operational prototype and tightened, if necessary, to provide more responsive deliveries. Similarly, the physical distribution of serviceable assets to combat units may need to be expedited to ensure the timely fulfillment of RBMS priorities.

New Procedures

Waiving and changing regulations and policies offer potential solutions to some problems. Sometimes, however, the most effective solution is to develop new procedures and capabilities.

Enable RBMS Users to Consider Real World Complexities. To deal with the issue of incorporating "real world" complexity into the operational prototype, (1) the prototype has to reflect the sources of complexity, (2) prototype test items should be chosen to minimize their importance, or (3) procedures need to be developed to adjust the RBMS priority lists to compensate for them.

In developing new procedures, the operational prototype should, if possible, incorporate how to deal with non-Army demands and configuration differences in repair and distribution priorities, if these are significant for the test items. Also, if the serviceable assets in the test are distributed differently from more than one geographic repair location, any geographic decision rules should be incorporated into the prototype. For example, IMs distribute serviceable TADS/PNVS components from five locations differently; one set of locations serves users in the European theater, the other set serves everyone else.

Expedite Unserviceable Delivery to Repair Shop. New procedures may be needed to ensure that unserviceables in stock are delivered promptly to the test repair shop to avoid constraining repair as prioritized by RBMS.

Use New Performance Measures. Earlier we discussed the need to waive the existing performance measures. But individuals still need to be evaluated, so new measures must be developed. Alternative performance measure can be developed and tested during the operational prototype, not only for participants but also for their superiors. For example, any weapon system measures applied at the MSC level need to be altered for the weapon systems affected by the test. The new performance measures need not simply measure compliance with RBMS priority lists, since there will be reasons to override them at times and barriers to doing so that are the control of RBMS users.

Repair shop performance might be measured in two ways: (1) how well it is able to follow the biweekly priority list and if not, why not (effectiveness), and (2) comparing actual hours spent on repairs completed versus standard hours for these repairs (efficiency). Measurement of IMs is complicated, for they are not expected to follow RBMS priority lists without review: there will be times these priorities need to be overridden. Those in supply functions in combat units supported by RBMS could be measured by how fast and accurately they update their asset positions in the electronic system RBMS depends upon, how quickly they return unserviceables, and how quickly they can deliver assets from their stock to their retail users.

Thoroughly Educating Prospective Users

Some of the problems identified (customer service versus worldwide weapon system availability; IM discretion versus RBMS and part of the mistrust of RBMS data) cannot be solved by waiving, changing, or developing policies and procedures. Solving them requires thoroughly educating users about RBMS—what it is, how it works, what it is designed to do (and not to do), how it determines priorities, etc. Such education, which often involves training, is critical to successfully implementing the prototype.

RBMS Data Are Best Available. The RBMS operational prototype will rely upon the best available data to set short-term priorities. During training, the various sources of data should be described to the users. If RBMS relies upon data sources users do not consider reliable, training should include a review of why these sources were chosen, any adjustments made to improve their accuracy, and, if possible, results of tests to show how reliable they are. Further, users can be urged to help improve the reliability of the data by identifying apparent errors during the test.

Users Must Understand Why and How RBMS Priorities Are Set. Requisitioners and IMs need to be convinced that following RBMS priorities will improve the Army's overall weapon system availability. Also, it would be helpful if IMs were given the tools to demonstrate this to retail users when responding to their questions, showing them that the Army is better off overall by following RBMS's priorities.

IMs must understand in depth *how* RBMS determines priorities and *what* information RBMS is using so they can judge when it is appropriate to override RBMS and for what reasons. Their feedback on how often they override RBMS and why will be critical to those evaluating the operational prototype. For example, when availability goals are equal, true NMCS demands (requisitions for items needed to make a weapon system mission capable) should be given precedence over RBMS lists, which are based on *expected* demand. Users will also need to be able to determine when more recent or accurate data (e.g., operating tempos or NFMC weapon systems) call for a RBMS override.

Given how fundamentally RBMS changes the repair and distribution prioritization process, it is critical that its users are well trained in the RBMS algorithm. Instead of relying only on passive training methods such as lectures or briefings, user training should include exercises to help the users grasp RBMS's approach. The RBMS demonstration package can be used as part of these exercises.

DESIGN CONSIDERATIONS FOR THE OPERATIONAL PROTOTYPE

Based on the problems identified, the solutions suggested, and other feedback from the interviewees, we suggest the following design considerations.

Provide Visibility for Users to See the Data RBMS Uses

Several IMs indicate that being able to refer to the data RBMS uses to produce the priority lists—asset positions by combat unit, operating tempos, and force postures—could help them better judge if and when such data had changed after the RBMS lists had been produced, thus calling for them to make a possible override.

Providing IMs with access to this information could also serve a second, perhaps more important, purpose. IMs sometimes also find that RBMS priorities are counterintuitive—it is sometimes difficult to predict what the next asset distribution will be to most improve the probability of achieving weapon system availability goals. If an IM can verify that RBMS is indeed relying on the most recent data available, the IM may be less likely to override RBMS's decision inappropriately.

Finally, visibility for the IM can help answer inquiries from would-be requisitioners for RBMS test items. IMs can tell inquirers what information RBMS is using and make adjustments if the inquirer can prove the information is incorrect.

Provide IMs with "What If" Capabilities

Several IMs suggest that they be able to use an RBMS operational prototype to test the effects of changes in the data RBMS relies upon and alternative distribution decisions on achieving worldwide weapon system goals. The first of these "what if" capabilities would be useful to an IM if he learned of changes in the data RBMS relied on to create a particular distribution priority list. Instead of guessing how the RBMS priorities would have changed given the changes in data, the IM could use the "what if" capability to *see* how RBMS's priorities would change.

The second "what if" capability (i.e., using RBMS to calculate the effects of an alternative distribution decision on weapon system availability) would be useful for IMs when field supply managers called to ask why they weren't receiving what they needed. An IM would be able to quickly see the relative probability of achieving weapon system goals across combat units and the marginal improvement due to following the RBMS priorities rather than honoring the inquirer's request.

Both these "what if" capabilities would also be useful during user training exercises to help users develop a deeper understanding of the RBMS algorithm.

To maintain the integrity of RBMS's data sources, both "what if" capabilities would need to be applied to a stand-alone RBMS, not to the actual RBMS operational prototype. They could be built as an adaptation of the current RBMS demonstration package, updated with current data each time RBMS distribution lists are produced.

Generate RBMS Distribution Lists as Often as Possible

The RBMS concept relies on using the most current "snapshot" of worldwide asset positions and conditions. Ideally, RBMS priorities should be recalculated each time these data change. Some repair work centers may be able to adjust their work schedules daily. In this case, RBMS repair lists during the operational prototype can be recalculated as often as data change. If a repair work center cannot easily change schedules this often, it may need to work with lists that are revised only every several days, weekly, or even biweekly.

In contrast, IM asset distribution decisions take less time and, by their nature, could follow more frequently produced lists. To increase the accuracy of RBMS priorities, we recommend that RBMS distribution lists be recalculated daily. This feature will reduce the frequency of times IMs will find inaccuracies in RBMS data for which they will want to compensate.

Give Production Schedulers On-Line RBMS Repair Lists

Production schedulers will use RBMS repair lists to develop workloads for technicians. Providing schedulers with an electronic version of the RBMS repair lists would help them convert these priorities to a batch schedule in a useful format. Further, the on-line version could be designed to facilitate monitoring progress against the priority list and tracking repair items set aside to await parts or repair of test stands.

The formats for any on-line RBMS screens should be designed in consultation with the schedulers on the items chosen for the operational prototype.

In the Longer Term, Show Goal Achievement Implications for Alternative Levels of Repair Resources

For workload planning and prepositioning of bits and pieces, the RBMS operational prototype will probably produce quarterly (or perhaps annual) priority lists. Such lists should show the mix of repairs under different assumptions of repair resources *and* the implications of each level of repair resource for achieving weapon system goals. For example, the RBMS list could show that the probability of achieving the goals would be "X" percent if "A" repair hours were available and "X + Y" if "A + B" hours were available. This information would be the first step to using RBMS in repair resource decisions and even in decisions about adding new test stands.

VI. FUTURE DIRECTIONS

NEXT STEP: AN OPERATIONAL PROTOTYPE

The RBMS demonstration prototypes successfully set the stage for further work by proving that RBMS data requirements can be met through normal channels, by suggesting that RBMS can offer worthwhile payoffs at all levels of the logistics system, and by prompting the identification of potentially troublesome policies and procedures that could have a bearing on both the usefulness and the usability of RBMS in the real world.

The next step in the RBMS test process is to develop a set of operational prototypes that extends these efforts. These will serve the dual purpose of exposing RBMS to real-world conditions and providing hands-on experience for potential users. Moreover, they will lay the groundwork for continued exploration and progress toward formal system implementation by permitting us to adapt the system operations to the realities of life.

Two operational prototypes are under development. The first involves using RBMS at Red River Army Depot (RRAD) to prioritize the repair and distribution of the major components—10 LRUs and 41 SRUs—of the multiple launch rocket system (MLRS) fire control system. This work center was chosen to demonstrate the effects of RBMS on normal peacetime depot operations. This exercise will demand extensive participation of many Army organizations: shop foreman and production controllers at RRAD, IMs at MICOM, Forces Command (FORSCOM) field units, and Army overseers from SLA, DESCOM, FORSCOM, MICOM, and RRAD. The second prototype places RBMS within a corps or division materiel management center, to be determined.

There are two major policy issues that we recommend be studied and tested with the operational prototypes. These concern distribution policy and how to redirect any assets incoming from higher echelons.

Distribution Policy

The operational prototypes provide the opportunity to test a mix of "push-pull" strategies that will help achieve the rapid responsiveness that will be demanded in operations such as short-term contingencies. One suggested solution is an anticipatory push to some forward location, such as a corps MMC, which would then respond to requisitions from engaged units. Between corps, lateral supply might be exploited through such systems as OSC. Another possibility is a push policy forward to units with a mechanism whereby units may refuse to accept the materiel if they perceive it as not necessary for their needs.

Just how far and how much to "push" is an open question that becomes less important as the Army moves to a much more responsive system (with order and ship times in days rather than possibly weeks) that can afford to remain as it is—reactive. Perhaps some types of actions (inducting unserviceables or pushing spares to a central disbursing location) should be made more proactive while others (distributing assets to requesting units) might remain reactive.

A push-pull mix will require a significant policy change in the Army in terms of ownership and accountability of spares, development of asset status systems, authority to move materiel, employment of units like the corps MMC, and the like. It will also involve some amount of methodological development of RBMS to allow it to exploit these new structures and policies.

Redirecting Serviceable Assets Incoming from Higher Echelons

During the time it takes serviceable assets coming from the rearward work center to reach their intended destinations in a theater of operations, the weapon system availability goals and operating tempos used to make distribution decisions may change. These changes may be significant enough to warrant redirecting or reallocating serviceable assets to locations that are different from those determined when the shipments took place.

There are at least two ways to divert resources incoming to the theater. One involves developing necessary management information systems to inform theater/corps MMCs of inbound assets and using a tool like RBMS to intercept and *redirect* assets to higher-priority locations. The other method allows the assets to move to their original destinations and then uses RBMS to *reallocate* them to higher-priority locations. The reallocation method would be simpler to develop, but it might not be as good a solution for wartime environments, where some original locations might be destroyed by enemy actions. People would probably try to divert shipments, but they would be doing so in an *ad hoc* manner without systems designed to help meet these needs; this could result in maldistributions that could adversely affect combat capability. The redirection capability might be more appropriate for theaters where there is no heavily developed logistics infrastructure. Further research is needed to determine how to divert incoming shipments within RBMS, and what policy should be used for the operational prototypes, if used at all.

BEYOND THE OPERATIONAL PROTOTYPE: OPEN QUESTIONS

The value of RBMS will be low if the Army merely implements it into existing structures with no changes in policies and procedures. Accepting RBMS into logistics and planning must be one part of an overall Army strategy for redesigning its structure for fast, responsive logistic support based on the concept of weapon system management. Extensive work needs to be done to lay out the policy and doctrinal changes necessary to implement weapon system management. The following paragraphs highlight key issues of concern to the development of RBMS.

Selecting the Work Centers and Items

As the demonstration prototypes showed, RBMS never adversely affects weapon system availability, but its value to a work center varies depending on the characteristics of the shop and the items it repairs. In an extreme case where a shop fixes only one item, RBMS would not be helpful in choosing what to fix next, but it could be useful in determining how many items to repair in a given time horizon. With regard to distribution, RBMS appears to have almost universal application—it enhances weapon system availability through more effective asset allocations.

These findings raise important concerns. For some repair work centers, the cost of collecting and managing the information needed to operate RBMS may be greater than the cost to "buy out" the stock necessary to operate a less responsive system to achieve the same weapon system availability objectives. In other cases, a more streamlined version of the system may be more appropriate. In any case, more research is needed to determine the characteristics of candidate work centers and the associated items to include in RBMS. Additional analyses should determine if the cost of implementing the system for all reparable items is much greater than the cost for implementing the system selectively fcr only the cost-effective centers.

Coordinating Multiple Work Centers

With its focus on the availability of entire weapon systems, RBMS must be able to coordinate workloads across shops that fix items on the same weapon. It needs the ability to dynamically rebalance workloads if constraints occur in one or more shops that prevent achieving specific weapon system availability goals. The current version of the DRIVE model must be enhanced to address this need for coordination.

Similarly, RBMS should be allowed to capitalize on shops with equivalent repair capabilities by making lateral repair actions. Decision criteria need to be developed and incorporated into the DRIVE model to answer the question: Under what circumstances should unserviceable assets be evacuated from a repair site that is swamped to another that can handle the work?

Connecting the Operations and Logistics Communities

The reliance of RBMS upon information from the operations planning arena emphasizes the importance of the apparent disconnect between operators and logisticians. More and more in a world of unpredictable operations, logisticians need better information about how operations will unfold if they are to be expected to provide the support needed to make those operations succeed.

Army commanders do not necessarily think explicitly about hard numbers of weapons they would like to have available and the operating tempos they need in a future time period for a given set of scenarios; thus, systems are needed to help elicit this information. Another concept paper in the VISION series dealing with the logistics C^2 system will outline one approach for accomplishing this function.

It may turn out that the C^2 segment of the VISION system cannot be as ambitious as the early design of the system may demand. RBMS may have to be modified to accept this eventuality. If logisticians are not made privy to commanders' plans, or if they cannot get precise information about expected operating tempos, RBMS may have to be changed to run on less specific data. One direction for redesign could be to permit RBMS to give relative prioritization to one unit over another, versus (in its current form) attempting to specify with greater precision exactly what steps need to be taken to meet weapon system availability goals. Although this would represent some degradation of the system, it would still preserve much of its value.

Adequate Stocks of Repair Parts

As discussed in Sec. V, the availability of adequate amounts of repair parts weighs heavily on the ability of RBMS to meet flexible repair schedules of higher-level assemblies. Obviously, assemblies that are NMCS at the depot for SRUs and bits and pieces or at lower echelons for SRUs greatly hinder weapon system availability. Strategies should be investigated to determine the most cost-effective way to maintain particular weapon system availabilities: how best to trade off cheaper bits and pieces against the cost of more expensive higher-level assemblies. The strategies pursued will differ depending on the items' characteristics, but emphasis must be given to efforts to ensure repair parts are available when needed, or RBMS will not produce the benefits it is capable of delivering.

Estimating System Costs

Our research to date has not attempted to determine the costs of developing and implementing RBMS within the Army. The costs of building such a system depend on several factors, including the range of items incorporated within the system, the number of echelons and work centers covered, and the efficiency of design. As work on the RBMS operational prototype proceeds, we hope to address costs.

Previous RAND research has influenced, to some extent, the design of the Air Force's Weapon System Management Information System (WSMIS) and Requirements Data Bank programs that include some of the ideas contained in this report. Although those systems cover other functions not discussed here, they may be appropriate analogies to determine the cost estimates for developing RBMS within the Army. In today's resource-constrained environment, they may also be worthy of study to determine if they could be modified to handle unique Army applications. If the Air Force systems were appropriate and if they could be easily modified to incorporate unique Army needs, the Army might save a significant amount of money.

Appendix A

OVERVIEW OF THE VISION PROJECT

The goal of the VISION (Visibility of Support Options) project is to improve the combat sustainability of U.S. Army forces through the use of enhanced combat service support (CSS) management techniques and decision support systems. There are three primary elements to VISION: an assessment system to aid sustainment planning; an execution system to guide repair and distribution decision-making; and a command and contol (C^2) system to connect the planning and execution functions by providing a link between the operations and logistics communities. Figure A.1 illustrates the relationships among the three systems.

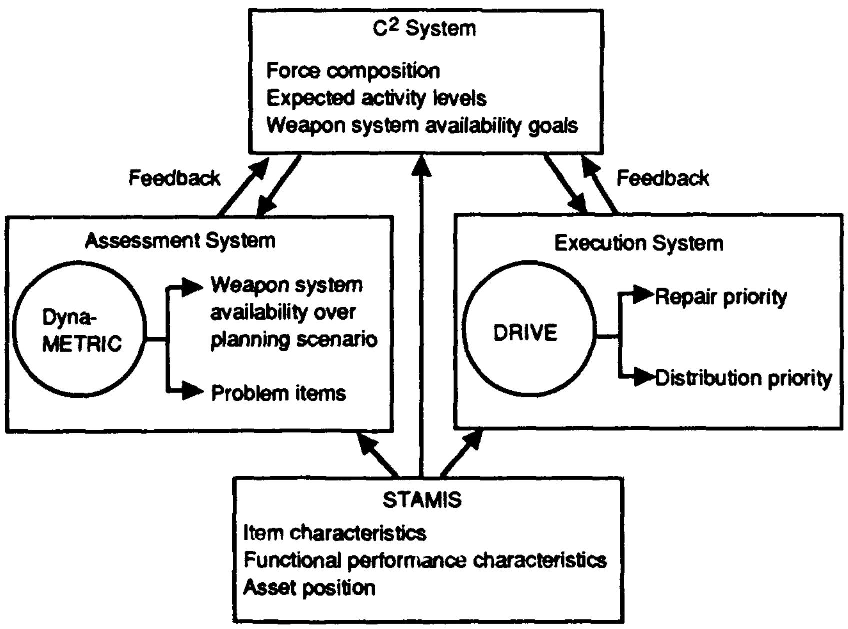

Fig. A.1—An integrated view of VISION C^2, assessment, and execution systems

CENTRAL THEMES OF VISION

VISION features three recurrent themes. The first is the replacement of traditional measures of logistics performance (e.g., supply fill rate or manpower utilization efficiency) by measures that are more relevant to warfighting capability. Among these, weapon system availability has received the greatest degree of attention and acceptance both in the Army and in the other services. Related measures, such as the attainability of planned weapon system activity levels in different combat postures, may also be worthy of examination.

Increasingly, the successful accomplishment of CSS missions depends upon the contributions of distinct—and often widely separated—organizations. As the level of interaction rises, effective coordination becomes more difficult. In recognition of this growing complexity, VISION's second theme is the integration of CSS activity across multiple functions and echelons in such a way that all participants work cooperatively toward the common goal of improved combat sustainability.

VISION's third theme underscores the importance of recognizing uncertainty and acting to overcome the disruptive effects of unanticipated events. An important consideration is the availability of up-to-date information about the status of the logistics system and the projected needs of the combat force. Such data can be used to guide decisionmaking and the formulation of adaptive strategies.

COMPONENTS OF VISION

The VISION C^2 System

At present, the VISION concept of C^2 is narrowly defined to include the translation of operational plans and goals into logistics needs, the transfer of that information to the assessment and execution systems, and the exchange of outputs among different assessment and execution system modules.[1]

Operational plans and goals are defined in terms of several parameters. Force composition identifies the size, organizational structure, and weapon systems of the combat units being supported. It may

[1]Eventually, the C^2 function may be broadened to provide for information transfer relating to other aspects of logistics support. Possibly, the VISION C^2 system could be embedded in larger Army management systems, such as the Combat Service Support Control System of the Army Tactical Command and Control System.

vary over the course of the planning scenario as units arrive and withdraw, or as forces are attrited during combat.

Activity level (or, alternatively, combat posture) defines the expected tempo of operations of the supported combat force. Like many logistics models, the Dyna-METRIC and DRIVE models found in the VISION assessment and execution systems assume that demands for spare parts are generated in proportion to operational activity. This may be measured in terms of operating hours, miles driven, rounds fired, or other. It may be necessary for the C^2 system to derive such factors from a qualitative statement of the commander's guidance (e.g., "Task force 1 advances to seize position A, task force 2 provides screening on the left flank, and task force 3 is held in reserve").

Operations goals should also reflect the commander's guidance and the requirements of the operations plan. They should be stated in terms of weapon system availability levels to be achieved. The goals may vary across the elements of a combat force. In the example above, for instance, task force 1 may require 95 percent availability of its M1 tanks, while task force 3 requires only 60 percent availability. The goal specification may be unilateral on the part of operations planners or it may reflect an iterative process in which availability rates are projected via the assessment system, evaluated by operations planners, and, if unsatisfactory, reassessed in view of potential changes in support plans.

The VISION Assessment System

The VISION Assessment System (VAS) is intended to be an integral part of the sustainment planning function. It allows planners at all levels to project weapon system availability over the course of any given operational scenario. It uses a logistics assessment model (Dyna-METRIC) first to compute the expected demands for logistics support arising from an operational plan, and then to evaluate the adequacy of logistics resources and functions (e.g., supply, maintenance, and transportation) for meeting those demands. In the course of performing this evaluation, VAS also identifies particular items and functions that are most likely to limit weapon system availability. VAS's ability to represent a wide range of alternative support policies allows it to be used in determining "get well" plans in the event that projected performance falls short of operational requirements.

VAS outputs serve two purposes. First, the projection of weapon system availability over time allows logistics planners to quantify the supportability of alternative operational plans. Projected availability may be compared to stated goals or, alternatively, it may be used to help establish the goals to be passed to the execution system. The second purpose is to identify the need for specific actions to improve projected performance. Such actions may include cross-leveling of spares among different units, sharing of repair resources, or longer-term modification of support structures and policies. In some cases, they may impose special requirements upon the execution system; if so, those requirements may be passed via the C^2 system.

The VISION Execution System

The VISION Execution System provides near-real-time decision support to maintenance and distribution managers at all levels in the system. It uses a prioritization algorithm (DRIVE) to orchestrate actions (which item to fix next and where to send it when it is fixed) on the basis of stated weapon system availability goals and operations plans. The execution system operates over short time horizons (ideally, no more than a few days) to retain maximum flexibility and responsiveness in the face of uncertainty. Thus, should there be significant departures from the anticipated course of events, the system can react quickly to establish new priorities.

VISION EXPLOITATION OF ADVANCED INFORMATION SYSTEMS

In addition to the operational plans and goals furnished via the C^2 system, the VISION assessment and execution systems rely upon up-to-date information about the status of the logistics system. Much of this can be provided by existing or new standard Army management information systems (STAMIS). Logistics data include descriptions of item characteristics (demand rates, indenture structure, repair times, etc.), asset positions (where items are held, in what quantity, and in what condition), and functional capabilities (e.g., repair and transportation capacities). Such data may be drawn from local sources by individual assessment and execution system modules, or they may be fed into the C^2 system for transfer to other locations as needed.

Appendix B

RBMS INPUT FORMAT SPECIFICATIONS

The RBMS input file consists of ten types of records. This appendix discusses their content, position in the input file, and required data format. In describing different data elements, we adhere to the following symbology:

- i denotes an integer.
- X.x denotes a real number.
- a denotes an alphanumeric character.

Data field widths are designated either explicitly (e.g., ii, XX.xxx, aaaa) or in terms of conventional FORTRAN usage (e.g., I2, F6.3, A4).

Data Structure

Type Record	
0	Administrative data
1	A block of unit description records, one for each unit
2	A block of unit program records, one for each unit
	A block of records for each LRU and its SRUs:
	For the LRU:
3	LRU description record
4	Shop status record
5	Unit status records (same order as Type 1)
	A block of SRU records:
	For each SRU:
6	SRU description record
7	Shop status record
8	Unit status records (same order as Type 1)
9	LRU holes (optional)

Administrative Data Record (Type 0)

Content: Specifies the number of units being modeled and provides general administrative information.

Position: There is only one Type 0 record in the input file, and it occurs before all other records.

```
Columns
         1         2         3         7         8
12345678901234567890123456789012345......01234567890

0 iiii aaaaaaaaa   iii X.xxxxxx aaa......aaaaaaaaaaa
| |    |           |   |        |
| |    |           |   |        general information
| |    |           |   sort value
| |    |           nominal lead time
| |    date
| number of units
record type
```

Col.	Format	
1	I1	Record type (should be 0).
3–6	I4	Number of units that exist within the scope of the exercise.
8–16	A9	Date (DD-MMM-YY) of the run or input data.
20–22	I3	Nominal lead time (induction lead time plus expected shop flow time), expressed in days. In essence, it is the number of days in peacetime when summed with the unit order and ship time. Combined with wartime it yields the planning horizon.
24–31	F8.6	Sort value (a number that determines the length of the lists to build). For a longer list, set this value closer to zero.
33–80	A48	General information for the user, such as a title.

Unit Description Record (Type 1)

Content: Identifies units (combat units and their SSAs), their assigned division and corps, OST from the rearward shop being modeled, and weapon system densities and availability goals. There is room for five types of weapons.

Position: Each unit requires a Type 1 record. All Type 1 records occur as a block immediately after the Administrative Data Record.

```
Columns
         1         2         3
1234567890123456789012345678901234567

1 aaaaaa aaaaaaa aaaa aa aaaaaaaa ii
| |      |       |    |  |        |
| |      |       |    |  |        order and ship time
| |      |       |    |  unit location
| |      |       |    corps
| |      |       division
| |      unit name
| DODAAC
record type
```

```
  4         5         6         7         8
89012345678901234567890123456789012345678901234567890123456

iiii iiii iiii iiii iiii X.xx X.xx X.xx X.xx X.xx
|    |    |    |    |    |    |    |    |    |
    Densities            Availability goals
WS1  WS2  WS3  WS4  WS5  WS1  WS2  WS3  WS4  WS5
```

Col.	Format	
1	I1	Record type (should be 1).
3–8	A6	Department of Defense Activity Address Code of the unit.
10–16	A7	Unit name.
18–21	A4	Division.
23–24	A2	Corps.
26–33	A8	Unit location (e.g., name of fort).
35–36	I2	Order and ship time between the rearward shop and the unit.
38–41	I4	Number of Type 1 weapons owned/ supported.
43–46	I4	Number of Type 2 weapons owned/ supported.
48–51	I4	Number of Type 3 weapons owned/ supported.
53–56	I4	Number of Type 4 weapons owned/ supported.
58–61	I4	Number of Type 5 weapons owned/ supported.
63–66	F4.2	Availability goal for Type 1 weapons.
68–71	F4.2	Availability goal for Type 2 weapons.
73–76	F4.2	Availability goal for Type 3 weapons.
78–81	F4.2	Availability goal for Type 4 weapons.
83–86	F4.2	Availability goal for Type 5 weapons.

Unit Program Record (Type 2)

Content: Describes the peacetime and wartime operating tempos of the units.

Position: Each unit requires a Type 2 record. All Type 2 records occur as a block immediately after the Unit Description Records (Type 1). Records must appear in the same order as Type 1 records—fields for DODAAC and unit name are not cross-checked for matches.

```
Columns
         1         2         3         4         5
123456789012345678901234567890123456789012345678901234567890123456

2 aaaaaa aaaaaaaaaaaaaaa a iiiii iiiii iiiii iiiii iiiii
| |      |               | |     |     |     |     |
| |      |               |  Peacetime operating tempo
| |      |               | WS1   WS2   WS3   WS4   WS5
| |      |               |
| |      |               peacetime repair capability
| |      unit information
| DODAAC
record type
```

```
    6         7         8
7890123456789012345678901234567 8

a iiiii iiiii iiiii iiiii iiiii
| |     |     |     |     |
|  Wartime operating tempo
| WS1   WS2   WS3   WS4   WS5
|
wartime repair capability
```

Col.	Format	
1	I1	Record type (should be 2).
3–8	A6	Department of Defense Activity Address Code of the unit.
10–24	A15	Unit information (name, division, corps).
26	A1	Peacetime repair capability (Y or N).
		(Y)es = unit possesses its own LRU repair facilities during peacetime, and can make use of SRUs shipped from the supporting facility;
		(N)o = no repair capability in peacetime.
28–32	I5	Peacetime operating hours/flying hours/rounds fired/... per month per weapon system of Type 1.
34–38	I5	Peacetime operating hours/flying hours/rounds fired/... per month per weapon system of Type 2.
40–44	I5	Peacetime operating hours/flying hours/rounds fired/... per month per weapon system of Type 3.
46–50	I5	Peacetime operating hours/flying hours/rounds fired/... per month per weapon system of Type 4.
52–56	I5	Peacetime operating hours/flying hours/rounds fired/... per month per weapon system of Type 5.
58	A1	Wartime repair capability (Y or N).
		(Y)es = unit possesses its own LRU repair facilities during wartime, and can make use of SRUs shipped from the supporting facility;
		(N)o = no repair capability in wartime.
60–64	I5	Wartime operating hours/flying hours/rounds fired/... per month per weapon system of Type 1.
66–70	I5	Wartime operating hours/flying hours/rounds fired/... per month per weapon system of Type 2.
72–76	I5	Wartime operating hours/flying hours/rounds fired/... per month per weapon system of Type 3.
78–82	I5	Wartime operating hours/flying hours/rounds fired/... per month per weapon system of Type 4.
84–88	I5	Wartime operating hours/flying hours/rounds fired/... per month per weapon system of Type 5.

LRU Description Record (Type 3)

Content: Identifies LRUs and provides demand rate, maintenance task distribution, and quantities per weapon system.

Position: Each LRU requires a Type 3 record, followed immediately by its Type 4 and 5 records. Records for indentured SRUs follow before the next set of LRU records.

```
Columns
          1         2         3         4         5
12345678901234567890123456789012345678901234567

3 M    aaaaaaaaaaaaaaa aaaaaaaaaaaaaaaaaaaa X.xxxxx X.xx
|      |               |                    |       |
|      |               |                    |      MTD
|      NSN             LRU nomenclature     demand rate
record type

                         6         7         8
                       8901234567890123456789012

                       iiii iiii iiii iiii iiii
                       |    |    |    |    |
                            Quantity per
                       WS1  WS2  WS3  WS4  WS5
```

Col.	Format	
1	A3	Record type (should be '3 M').
8–22	A15	LRU stock number.
24–43	A20	LRU nomenclature.
45–51	F7.5	Demands per weapon system operating hour/ flying hour/... (same usage basis as in Type 2 records).
53–56	F4.2	Proportion of total demands that are sent to the rearward repair facility for repair.
58–61	I4	Quantity installed on weapon system 1.
63–66	I4	Quantity installed on weapon system 2.
68–71	I4	Quantity installed on weapon system 3.
73–76	I4	Quantity installed on weapon system 4.
78–81	I4	Quantity installed on weapon system 5.

LRU Shop Status Record (Type 4)

Content: Provides each LRU's repair characteristics and current asset position at the rearward repair facility.

Position: Each LRU requires a Type 4 record appearing immediately after the associated LRU Description Record (Type 3).

```
Columns
         1         2         3
123456789012345678901234567890

4 aa XXX.x X.xx iiii iiii iiii
| |  |     |    |    |    |
| |  |     |    |    |    in maintenance
| |  |     |    |    unserviceables on hand
| |  |     |    serviceables on hand
| |  |     final recovery rate
| |  repair time
| test station/shop name
record type
```

Col.	Format	
1	I1	Record type (should be 4).
3–4	A2	Name of the shop or test station that fixes the LRU.
6–10	F5.1	Standard number of hours required to complete on-station repair (include multiple cycles).
12–15	F4.2	Proportion of unserviceables sent to the shop that are repaired and made serviceable.
17–20	I4	Number of serviceables (condition code A) on hand at the shop.
22–25	I4	Number of unserviceables (condition code F) on hand at the shop.
27–30	I4	Number in maintenance (condition code M) at the shop.

LRU Unit Status Record (Type 5)

Content: Provides the LRU's asset status and application fraction at each unit.

Position: Each LRU requires a Type 5 record appearing immediately after the associated LRU Shop Status Record (Type 4).

```
Columns
         1         2         3         4         5
12345678901234567890123456789012345678901234567890

5 aaaaaa aaaaaaaaaaaaaaa iiii iiii iiii iiii iiii
| |      |               |    |    |    |    |
| |      |               |    |    |    |    holes in weapon systems
| |      |               |    |    |    unserviceables in transit
| |      |               |    |    serviceables in transit
| |      |               |    in maintenance
| |      |               serviceables on hand
| |      unit information
| DODAAC
record type

             5         6         7
             12345678901234567890123 4

             X.xx X.xx X.xx X.xx X.xx
             |    |    |    |    |
              Application fractions
             WS1  WS2  WS3  WS4  WS5
```

Col.	Format	
1	I1	Record type (should be 5).
3–8	A6	Department of Defense Activity Address Code of the unit.
10–24	A15	Unit information (name, division, corps).
26–29	I4	Number of serviceables (condition code A) on hand at the unit.
31–34	I4	Number in maintenance (condition code M) at the unit.
36–39	I4	Number of serviceables in transit from the shop (rearward repair facility).
41–44	I4	Number of unserviceables in transit to the shop (rearward repair facility).
46–49	I4	Number of holes (due-outs) in weapon systems for this LRU.
51–54	F4.2	Proportion of Type 1 weapon systems on which the LRU is installed.
56–59	F4.2	Proportion of Type 2 weapon systems on which the LRU is installed.
61–64	F4.2	Proportion of Type 3 weapon systems on which the LRU is installed.
66–69	F4.2	Proportion of Type 4 weapon systems on which the LRU is installed.
71–74	F4.2	Proportion of Type 5 weapon systems on which the LRU is installed.

SRU Description Record (Type 6)

Content: Identifies SRUs, provides demand rate, and relates SRUs to their parent LRUs.

Position: Each SRU requires a Type 6 record, followed immediately by its Type 7 and 8 records.

```
Columns
         1         2         3         4         5         6
1234567890123456789012345678901234567890123456789012345678901

6 M    aaaaaaaaaaaaaaa aaaaaaaaaaaaaaaaaaaa X.xxxxx iiii X.xx
|      |               |                    |       |    |
|      |               |                    |       |    replacement %
|      |               |                    |       quantity per LRU
|      NSN             SRU nomenclature     demand rate
record type
```

Col.	Format	
1	A3	Record type (should be '6 M').
8–22	A15	SRU stock number.
24–43	A20	SRU nomenclature.
45–51	F7.5	Demands per weapon system operating hour/ flying hour/... (same usage basis as in Type 2 records).
53–56	I4	Quantity per parent LRU.
58–61	F4.2	Replacement fraction: proportion of unserviceable parent LRUs sent to the repair facility on which the SRU is broken. Cannot exceed the application fraction on the Type 5 record.

SRU Shop Status Record (Type 7)

Content: Provides each SRU's repair characteristics and current asset position at the rearward repair facility.

Position: Each SRU requires a Type 7 record appearing immediately after the associated SRU Description Record (Type 6).

```
Columns
         1         2         3         4
1234567890123456789012345678901234567890

7 aa XXX.x X.xx iiii iiii iiii      X.xx
| |  |     |    |    |    |         |
| |  |     |    |    |    |         application fraction
| |  |     |    |    |    in maintenance
| |  |     |    |    unserviceables on hand
| |  |     |    serviceables on hand
| |  |     final recovery rate
| |  repair time
| test station/shop name
record type
```

Col.	Format	
1	I1	Record type (should be 7).
3-4	A2	Name of the shop or test station that fixes the SRU.
6–10	F5.1	Standard number of hours required to complete on-station repair (include multiple cycles).
12–15	F4.2	Proportion of unserviceables sent to the shop that are repaired and made serviceable.
17–20	I4	Number of serviceables (condition code A) on hand at the shop.
22–25	I4	Number of unserviceables (condition code F) on hand at the shop.
27–30	I4	Number in maintenance (condition code M) at the shop.
37–40	F4.2	Proportion of the parent LRU on which the SRU is installed.

SRU Unit Status Record (Type 8)

Content: Provides the SRU's asset status at each unit.

Position: Each SRU requires a Type 8 record appearing immediately after the associated SRU Shop Status Record (Type 7).

```
Columns
         1         2         3         4
12345678901234567890123456789012345678901234

8 aaaaaa aaaaaaaaaaaaaaa iiii iiii iiii iiii
| |      |               |    |    |    |
| |      |               |    |    |    unserviceables in transit
| |      |               |    |    serviceables in transit
| |      |               |    holes in parent LRU
| |      |               serviceables on hand
| |      unit information
| DODAAC
record type
```

Col.	Format	
1	I1	Record type (should be 8).
3–8	A6	Department of Defense Activity Address Code of the unit.
10–24	A15	Unit information (name, division, corps).
26–29	I4	Number of serviceables (condition code A) on hand at the unit.
31-34	I4	Number of holes in LRUs in maintenance (causing the LRUs to be NMCS). Enumerate the holes in Type 9 records.
36–39	I4	Number of serviceables in transit from the shop (rearward repair facility).
41–44	I4	Number of unserviceables in transit to the shop (rearward repair facility).

LRU Holes Record (Type 9)

Content: Enumerates the holes in NMCS LRUs in maintenance (condition code M) at the repair facility.

Position: Type 9 records are optional. There is one record for each LRU that has a hole and is NMCS at the repair facility. These records occur in blocks after the Type 8 records associated with each LRU (i.e., not after SRU-specific Type 8 records).

```
Columns
         1         2         3         4
1234567890123456789012345678901234567890

9 aaaaaaaaaaaaaaa aaaaaaaaaaaaaaa iiii i
| |               |               |    |
| |               |               |    initial record indicator
| LRU NSN         SRU NSN         number of holes
record type
```

Col.	Format	
1	I1	Record type (should be 9).
3–17	A15	Stock number of the LRU with the hole.
19–33	A15	Stock number of the SRU for which a hole exists.
35–38	I4	Number of holes of the named SRU in the named LRU. Cannot exceed the SRU's quantity per LRU.
40	I1	Indicates whether this is the first Type 9 record for a particular LRU unit. 1 indicates the first hole, 0 indicates an additional hole.

For example, two LRUs of the same type, the first with four holes and the second with two holes, might look like this:

```
9  1234011115678   5555012223333   1  1  <--  first record for 1st LRU
9  1234011115678   5555013334444   3  0
9  1234011115678   5555012223333   1  1  <--  first record for 2nd LRU
9  1234011115678   5555014446666   1  0
```

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